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AN ACCOUNT OF THE RISE OF NAVIGATION.

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One of the most obvious practical benefits directly traceable to astronomical research is found in the application of celestial observations to the solution of the problems of navigation. Though other sciences have contributed their quota, it is mainly astronomy that has made the ocean safe for the navigator.

The fundamental problem of Navigation is: Given the position on the earth of the port to be reached, to determine the ship's positions and the best courses to be steered at suitable intervals from the beginning to the consummation of the voyage. This problem, so important commercially, is strictly speaking one of science, for it depends chiefly for its accurate solution on the application of the principles and methods of practical astronomy.

For obvious reasons the accuracy attainable in determinations of position and direction at sea is much inferior to that possible on shore. The unsteadiness of the platform of a ship, the uncertainties of atmospheric refraction near or on the horizon, and the intervention of cloudy periods while the ship is progressing through disturbing currents and winds are formidable difficulties which the navigator must meet. But the results attainable with care leave only a small element of risk affecting modern transportation at sea.

Quite different was the position of the navigator in early times. The compass was introduced generally into Europe about 1400 A. D. Before this time the only practical means of navigating a ship on the Atlantic and Mediterranean was to keep in sight of land, or occasionally, for short distances, to direct the ship's course by reference to the sun and stars. But this very rough method failed in cloudy weather, and even during short voyages on the Mediterranean in such circumstances the navigator became hopelessly bewildered as to his position. Frequently, on the China Sea and the Indian Ocean, vessels were able to traverse long distances out of sight of land by running directly before the steady

winds, called the monsoons, which prevail in those localities. But the compass was an important adjunct even there, and such methods of navigating were makeshifts at best.

The general adoption of the mariner's compass, about 1400 A. D., was followed by a period of progress in Navigation, particularly among the Portuguese, whose exploring expeditions during the fifteenth century led to important discoveries in the Atlantic. Prior to this time the methods in use were very rude, uncertain and dangerous. When a fleet of merchant vessels was sent to distant ports the trader was content if one or two returned and he fixed the prices on his precious imports accordingly.

But even at the beginning of the seventeenth century Navigation was still in a very backward state. That the compass needle does not point true north had been noticed early; that the amount of variation from north was different for different localities had been noted by Columbus or Cabot about 1490; but that the variation of the compass changes from year to year at the same base was not known until 1635.

At this time (about 1600) a navigator's equipment included: a compass for directing the course; a rough weight and line for making soundings: a cross-staff or astrolabe for measuring angles; a fairly good table of the Sun's distance north or south of the equator; and corrections for the altitude of the pole star. The last four appliances were used solely to determine the latitude or the distance on the earth's surface north or south of the terrestrial equator. Occasionally a very incorrect chart helped determine the ship's position. In this connection the motion of the ship was usually determined by estimating the speed every two hours or so, or, in some cases, by throwing out a float from the bows of the ship and noting the interval of time between its passage abeam of two observers standing on the deck at known distances apart.

By observations with the cross-staff and astrolabe on the Sun or the pole star, latitude could be measured at sea with sufficient accuracy to fix the observer's position north or south of the equator within twenty miles or so, but no method was available for finding longitude, or position east or west on the earth, except the rough expedient of estimating the run of the ship, taking wind, tide, and current into account. The only mode of arriving at a port of destination was to steer so as to get into the latitude of such a port either to the eastward or westward of its supposed position, and then to approach it on its parallel of latitude by steering a course due east or west. Obviously this method, though the best then available, might prove fatal if the error in longitude were too great.

The advice on longitude finding given by a nautical authority of repute at this time illustrates well the status of the problem up to the eighteenth century. He observes, "Now there be some that are very inquisitive to have a way to get the longitude, but that is too tedious for seamen, since it requireth the deep knowledge of Astronomy, wherefore I would not have any man think that the longitude is to be found at sea by any instrument; so let no seamen trouble themselves with any such rule, but (according to their accustomed manner) let them keep a perfect account and reckoning of the way of their ship." Such a record of the way of a ship appears to have been made with chalk on a wooden board called a log board which folded like a book and from which each day a position for the ship was deduced.

But while the longitude problem at sea remained unsolved, contributions to progress in Navigation were being made in other directions. Mercator and Wright developed a correct sailing chart about 1600. Gunter's tables in 1620 made possible the application of logarithms to Navigation. In 1631 a device, called the vernier, for accurate reading of scales became known. In 1635 Gellibrand published his discovery of the annual change in the variation of the compass needle. In 1637 Norwood helped remove one of the greatest stumbling blocks in the way of correct navigation by determining improved values of the length of a minute of arc on the the earth's surface, or the true nautical mile. His value was about six per cent too large. In 1699 Halley constructed the first compass variation chart.

In the meantime some progress was being made with the longitude problem. It was recognized that the only accurate method of determining the longitude is by knowing the difference at the same instant between the time at the meridian of Greenwich and that of the observer. The determination of the local time for the observer by astronomical observations of the altitude of suitably situated heavenly bodies was an old, well-known and frequently practiced operation. But the simultaneous determination of Greenwich time presented great difficulties. Obviously if the ship were near enough to a station on the Greenwich meridian a rocket or a loud explosion could be used as a signal at some stated Greenwich time. The ship's time for the same instant could then be observed and the difference between these two times for the same instant would be the longitude of the ship east or west of Greenwich. But for ships out of signal range from Greenwich observations of celestial phenomena had to be employed. At present chronometers are carried on board ship which, after being corrected and rated at departure, keep accurate Greenwich time throughout the voyage and thus render longitude determination relatively easy. But chronometers of satisfactory accuracy were not available till late in the eighteenth century.

The best method known for determining Greenwich time at sea by observation before the chronometer became available was that depending upon the measurement of the distance of the Moon from selected stars. For the Moon makes a rapid circuit of the sky once each month and in so doing passes close to a number of bright stars. Hence if the navigator can be provided with tables giving the Greenwich time when the Moon should be found to be distant from a given star by a given amount which he has measured, then the Greenwich time of the instant of that observation becomes known and may be kept by an hour glass or watch for a few minutes while the ship's time is being found.

This method for determining longitude was foreseen as early as 1514 but its practical application was attended with difficulties, not surmounted indeed before another and better method had been developed through the invention of the accurate chronometer. The difficulties in the way of the lunar distance determination of longitude were imperfect knowledge of the Moon's motion and the crude character of the instruments for measuring angles, together with some inferiority inherent in the method.

The study of the longitude problem was stimulated by a prize of 1000 crowns offered by Philip III of Spain, followed by another of 10,000 florins by the States-general for the discovery of a method of finding longitude at sea. As a result it was brought out that methods depending on the Moon's position offered the best solution at that time but that the lunar tables extant were useless and that much study and observation would be necessary to make them available. Primarily to attack this lunar problem England established her national observatory, in 1675. Fifty-six years later the Astronomer Royal in charge of the Greenwich Observatory announced that he hoped to be able to compute the Moon's position within such limits that longitude errors would be reduced to sixty miles at the equator. Apparently progress had been slow.

In 1714 England's "Commission for the discovery of longitude at sea" had been constituted with power to grant large sums in prizes. For a method of determining the longitude within sixty geographical miles, to be tested by a voyage to the West Indies and back, ten thousand pounds was offered; within forty miles, fifteen thousand pounds; within thirty miles, twenty thousand pounds.

The importance of further progress in methods of Navigation at this time is brought out by accounts of actual casualties showing what the dangers were. Admiral Wheeler's squadron, in 1694, leaving the Mediterranean, ran on Gibraltar when they thought they had passed the Strait. Sir Cloudesley Shovel's squadron, in 1707, was lost on the

rocks off Scilly, by erring in their latitude. Several transports, in 1711, were lost near the St. Lawrence river, having erred forty-five miles in their reckoning. Lord Belhaven was lost on the Lizard in 1721, the same day on which he sailed from Plymouth, England.

At this point two most vital discoveries making for advancement in Navigation were made. The rise of modern navigation may fairly be dated from the invention of the sextant by Hadley in 1731 and of the chronometer by Harrison in 1735.

The sextant is an instrument for the measurement of angular distances. As such it replaced the cross-staff and the astrolabe, than which it is far more convenient and accurate. The cross-staff required the observer to sight in two directions at once, while the sextant forms two images of the object or objects observed as near together as desired in a small telescope. The astrolabe was suspended and was supposed to be kept plumb by gravity, but the movement of the ship rendered accuracy impossible. Three observers were required to manipulate it. The sextant is easily handled by one observer, who, with practise, soon acquires great proficiency and accuracy in the measurement of angles although his position may be on the unsteady deck of a ship at sea.

The chronometer is a time piece like a watch in that it is actuated by a spring and depends upon a balance wheel for the measurement of time. It is however much larger and usually much more accurate than a watch; and it is mounted on gymbals so that it may by its own weight remain face up when its case is tipped.

In early times mariners used the compass as a rough sun-dial for the determination of time. Water-clocks and sand-clocks were employed for rough purposes of keeping time on board ship and it is curious to note that hour and half-hour sand glasses were used in the British navy until 1839. When watches were introduced in 1530 they were not accurate enough to supersede even the primitive devices then in use. The practical difficulty arose from their very irregular rates, owing to change in temperature and the motion of the ship. Harrison's great invention, which made possible the chronometer and greatly improved the watch, was the principle of compensating the balance wheel by the use of two metals with different coefficients of expansion, together with a device by which the chronometer retains its motion while being wound.

Harrison was eager to try for the longitude prizes with the help of his new invention. He believed that his time-piece, if set and rated carefully before embarking, could be relied upon to keep Greenwich time for a voyage of several months with such accuracy that greatly improved longitude determinations at sea could be effected. In 1735 he was allowed to test one of his first watches on a voyage to Lisbon,

with a result so satisfactory that he received a grant of 500 pounds to carry out further improvements. The official trial journey to the West Indies was begun in November, 1761, with an improved chronometer; and during the whole voyage of five months the total error unallowed-for was 1 min. 54.5 sec. or the equivalent of 18 miles in the latitude of Portsmouth, an amount well within the limit of 30 miles specified for the grand prize of the Longitude Commission.

Apparently Harrison had won the prize of nearly $100,000.00; but the invention of the sextant, which had helped Harrison by facilitating the determination of local time, had been especially favorable to certain powerful competitors who hoped to gain the reward by measurement of lunar distances from stars. Much improved lunar tables had been submitted by Mayer in 1755. These were pronounced generally correct within a minute of arc; and Maskelyne, after a trial voyage to St. Helena in 1761, during which he determined longitudes within 90 miles or so, prepared a guide, issued in 1763, in which he asserted his belief that the lunar method would determine longitudes always within 60 miles on the equator and generally within 30 miles, if applied to careful observations. Encouraged by this progress, though the process involved was too laborious for seamen to undertake, the House of Commons withheld the prize from Harrison and left an open chance for a lunarian during four years from 1763.

In March, 1764, on another trial voyage to the West Indies, Harrison's watch made a record even better than before, running four months with an error not greater than ten miles in longitude. Accordingly in the following year he was awarded one-half of the prize of twenty thousand pounds; but at the same time, authority and funds were given for the publication of the Nautical Almanac, containing among other things tables of the Moon's distance from the Sun, when suitable, and from seven fixed stars at intervals of three hours. Apparently the longitude commissioners were still on the fence.

The tables of lunar distances in the Nautical Almanac, together with Maskelyne's auxiliary tables, facilitated greatly the lunar method for finding longitude. But steady progress toward the perfection of the chronometer maintained the superiority of the chronometer method of longitude determination, and soon after 1800 the longitude controversy may be considered to have been settled in favor of the accurate time-piece.

The marvellous accuracy of the modern chronometer—of even the cheaper chronometers used in the mercantile marine—is illustrated by the steamship Orellana sailing from London to Valparaiso. In a voyage of sixty-three days the mean accumulated error of her three chronometers was only 2.3 seconds of time, or one-half a mile in longitude at the equator—and less in higher latitudes.

At the present time, since the Greenwich time can be sent out by wireless from shore stations, in the problem of longitude determination even less dependence need be placed on the chronometer, and the accuracy of such determinations is not necessarily appreciably different from that of latitudes.

Equipped with the compass and log, sextant, chronometer, lead, Nautical Almanac, and the *Requisite Tables* the navigator was ready to sail with comparative safety over long voyages early in the nineteenth century. The crying need was for more and better charts and for better knowledge of tides, winds and currents. The establishment of the Admiralty Hydrographic Office of Great Britain in 1795 marked a great step in advance in these directions. The first official catalog of the Admiralty, issued in 1830, listed 962 charts. And in 1832 official tide tables were issued also by the Admiralty. At present the navigator's charts cover all the important coasts and seas, with very full data of tides, winds and currents.

In the United States marine chart work began in the Navy Department in 1837. From 1844 to 1861, the United States Observatory and Hydrographic Office under Lieutenant M. F. Maury devoted itself not only to astronomical and hydrographic work but also to important research in marine meteorology. This period is notable for the issuance of Maury's famous "Wind and Sailing Charts" and "Sailing Directions", It was Maury's wish that the Wind and Sailing Charts should be an exclusively American contribution to world Navigation. In 1866 the hydrographic and meteorological branches were disconnected from the Naval Observatory and given to the present Hydrographic Office, and in 1904 the work of marine meteorology was transferred to the Weather Bureau. The United States Hydrographic Office conducts marine surveys, collects information for nautical publications, and prepares manuals, charts, sailing directions and nautical tables for the use of navigators generally. In a single year it prints about four hundred thousand charts and many more pamphlets and bulletins. It sells about one hundred thousand charts and books to navigators each year. The United States Coast and Geodetic Survey prepares and distributes tide tables and also charts and pilots of our coasts.

In recent times the great development of modern ships in both size and speed has increased enormously the demands on those who command and navigate them and has led to careful study and improvement of methods in Navigation. Simplified procedure, better tables, and a higher standard of preparation of the navigator have been realized. On the instrumental side the sextant and chronometer have been carried toward perfection, the sounding machine much improved and the gyro-compass introduced. The original model of one of the

best modern types of magnetic compass was patented by Lord Kelvin in 1876. The gyro-compass is used side by side with the magnetic compass but cannot be said to have superseded it. The rotary or patent log came into general use about 1836, but was introduced in the form usually employed at present in 1878. It records the revolutions of a small screw towed by the ship and, like a speedometer, registers the speed of the ship and the distance run at any instant.

The important features of modern practice in Navigation may be brought out by a brief account of methods now employed. In planning out in advance a long ocean voyage the navigator would first lay down on a chart the track from port to port. It would be his object to adopt the shortest route available, taking into account currents, winds, ice and other undesirable features of high latitudes, as well as specified lanes of traffic, and the intervention of land. Since the great circle route is always shorter than any other, especially between ports far apart in longitude and in high latitudes of the same name, a great circle chart is often used, for on such charts a great circle appears as a straight line. But since the track will be transferred finally from the great circle chart to one on a Mercator's projection, which is more convenient for purposes of navigation, the course may be entered in the beginning on a Mercator's chart using the method proposed by Airy for drawing approximate great circles. On a Mercator's chart the track followed by a ship steering a continuous course is a straight line (technically known as a rhumb line), and since ships rarely, if ever, steer on great circles and, instead, follow a series of rhumb lines like chords of the great circle track, differing successively one or two degrees in direction, it is desirable to use a Mercator's chart upon which each such course appears as a straight line.

Having thus planned the most advantageous general track to follow, three methods are used to determine the position of the ship at any time during the voyage: these are (1) projecting the track on charts; (2) simple trigonometrical calculations based upon the course steered and distance run as shown by compass and log; and (3) astronomical observations with sextant and azimuth circle.

Of these the first is generally least trustworthy owing to the unavoidably small scale of the charts. But when a ship approaches or leaves a coast, chart sailing becomes obligatory and large scale charts are available for the purpose.

On leaving harbor, the so-called point of departure is found, possibly by astronomical observations but preferably by sighting on objects on shore as mapped on the chart of the port. In hazy weather especially, a continuous line of soundings at fairly even distances apart affords an

additional control on one's position, and for this purpose the sounding machines invented by Lord Kelvin, permitting satisfactory soundings at speed of 15 or 16 knots, are most useful.

While in sight of land the course can be followed best by land sights and soundings, a method of navigation usually referred to as piloting. Before losing sight of land the longitude and latitude of the last well-determined position found by methods of piloting is taken from the coast chart and transferred to the ocean or small scale chart and is considered as the point of departure.

The point of departure is the starting point of the ocean voyage; and from that point the course and distance are laid down, being rectified whenever astronomical observations are available. More accurately, though less vividly than on the chart, the changes in longitude and latitude involved in each change of course are computed by plane trigonometry, using so-called traverse tables for the solution of the right-angled triangle involved. Such a method of keeping account of a ship's position on the basis of the course as indicated by the compass and the distance as indicated by the log, allowing for wind, current, and tide, is called dead reckoning. As bearing upon the accuracy of the log, it is interesting to note that some authorities, in the case of of steam vessels, consider that the revolutions of the ship's propeller, taking into account the condition of the ship's bottom, afford the best means of estimating speed.

Astronomical reckoning affords the most accurate means of ascertaining positions at sea, dead reckoning being carried along partly as a check but also to be relied on when weather does not permit observations of the heavenly bodies.

Navigators will generally prefer to determine position from observations of the Sun, measuring the altitude of that body above the sea horizon. But similar observations of the planets and brighter stars in twilight, when the horizon is still well defined, afford even better determinations of positions at sea. In such a case the careful navigator, by observing for latitude two stars, one north and one south of the zenith, and for longitude two stars, one east and one west of the zenith can depend on a good result, especially if the stars in each pair are about at the same altitude and not too low in the sky. Since the Moon also may be used when occasion arises, it is evident that the navigator seldom needs to go long without a good fix or determination of position.

The chief astronomical observations made at sea are those for ascertaining (1) latitude, (2) time and longitude, (3) compass error, and (4) latitude and longitude simultaneously.

The general aim among navigators, excepting perhaps the more progressive, is to observe with a sextant the altitude of the Sun in the morning when that body is nearly above the east point, to determine local time and longitude. In the computation of local time it is necessary to adopt a latitude obtained by dead reckoning, but if the Sun is well placed errors in the assumed latitude will introduce relatively small errors in the resulting ship's time. The longitude is obtained by taking the difference between the ship's time and the corresponding Greenwich time recorded by the ship's chronometers. This longitude is carried forward to the following noon by dead reckoning. The latitude at noon is determined by measuring the altitude of the sun on or very near the meridian. Another time sight may be made before sunset. Or if stars are used at twilight one is observed east or west for longitude and another north or south for latitude. A longitude by dead reckoning may be used first to derive the latitude and then with the observed latitude the longitude may be obtained, though in unfavorable cases more trials may be necessary.

The newer methods, which are rapidly superseding other modes of ascertaining a ship's position, are based upon the use of the Sumner line of position. In these methods each sextant altitude of a heavenly body is used to determine all it ever can actually give, a line on the sea on which the ship must be situated. Such a line, though in practice nearly always sensibly straight, is in reality an arc of a small circle on the earth's surface having its center immediately under the celestial object observed with a radius equal to the zenith distance of that object. The Sumner line may be defined by two points, in which case two longitudes or two latitudes are assumed or derived by dead reckoning and the other coördinate computed. Or the line may be defined by one point derived in this or a similar way together with the direction of the line, which will be at right angles to the direction of the body observed, at the time of the observation. If the Sumner point, thus used in defining the Sumner line, is to be adopted as a point of departure, it is important that it should be a probable position, taking advantage of the evidence furnished by dead reckoning. In the Marc St. Hilaire method, which is generally preferred, this point is the intersection of the Sumner line with the vertical plane of the celestial object observed, assuming for the observer the position obtained by dead reckoning.

Some help toward an understanding of Sumner's method will be found in an account of its discovery. Sumner sailed from Charleston, South Carolina, in November 1837, bound for Greenock, England. After passing longitude 21° W, about 800 miles west of London, no observations could be made until soundings had indicated that the ship was

near land. About midnight of December 17, dead reckoning indicated that the ship was within forty miles of Tuskar light off the Irish coast opposite Wales, and the ship stood off the supposed shore to await developments. About ten o'clock the next morning an altitude of the sun was observed and the chronometer time noted, but, having run so far by dead reckoning, it was plain that the knowledge of the latitude was not sufficiently reliable to afford a determination of longitude. Nevertheless Sumner computed his longitude, using the latitude by dead reckoning, and got a position 15′ east of that by dead reckoning. Then in order to determine how far errors in his assumed latitude would affect the computed longitude he assumed a second latitude 10′ farther north and got a position twenty-seven miles ENE of the former position and toward the danger. A third assumed latitude still farther north gave a third point twenty-seven miles still farther ENE of the first point. Upon plotting these positions on a chart they were seen to be on a straight line and this line passed through Small's light off the coast of Wales. Credit is due Sumner because he realized then that anywhere on the line he had determined the altitude of the sun at the time of observation would have had the value he measured, and that such would be the case only on that line. He therefore assumed that he was on that line and, keeping his course ENE along it made Small's light in less than an hour. After hours of uncertainty off a rocky lee shore in the midst of a winter gale what must have been Captain Sumner's relief when the lighthouse appeared ahead. Later it developed that at the time of his uncertainty his latitude by dead reckoning was eight miles too far south and his longitude forty-five miles too far west. The result to the ship might have been disastrous had the wrong position been adopted.

In using Sumner's method in its simplest form, altitudes are measured of two suitable objects in quick succession or of the same object at two suitable times. Each observation gives a line upon which the ship must be situated. The intersection of these two lines of position gives the position of the ship. If the two observations are separated in time and the ship is moving, dead reckoning must be used to allow for the ship's change in position between observations.

Important advantages of the line of position methods are not hard to find. Every observation for position is treated in the same way. The method makes clear to the navigator how much information his observation actually yields. With available tables, including Lord Kelvin's Sumner Line Table, the calculations may be completed entirely without logarithms and with a minimum amount of work. When the value of the newer methods is realized by navigators it is not to be doubted that calculations for position will be based universally on the Sumner line.

In considering the foregoing methods of fixing astronomically the position of a ship it is evident that, always when the two elements of latitude and longitude are determined at different times and frequently when they are determined by Sumner's method, the navigator has to depend partly on dead reckoning; also during cloudy weather out of sight of land he has to depend entirely on this method for his knowledge of the ship's position. Clearly then frequent determination of the error of the compass is a most important duty. In practice this error is found very simply by comparing the compass bearing or direction of a heavenly body with its bearing, determined by calculation if necessary, but usually taken from a table.

The total error of the compass includes that due to actual known variation of the needle and also that due to deviations caused by the attraction of the iron of the ship. The former error can be found from charts and easily allowed for, but the latter is variable and uncertain and thus makes necessary the frequent determination of compass correction. It is customary to reduce the deviation error as much as practicable by the use of artificial magnets, as well as spheres and bars of soft iron, mounted about the compass before the ship leaves port, but no arrangement known effects a permanent correction.

A careful record of everything pertaining to the navigation of the ship with the results of all observations and calculated positions is kept in an official book, called the Ship's Log. Each day at noon the ship's position is computed by dead reckoning from the previous noon and also by astronomical observations, when such are available. The course and distance made good from the previous noon are then computed using astronomical position if available. Finally the course and distance are computed from the position of the ship at noon to either the port of destination or some prominent position or danger near which the vessel must pass.

The needs of our rapidly expanding naval forces and the demand of our new merchant fleet for thousands of officers have centered attention in instruction for the preparation of navigators. The Shipping Board schools, the naval schools and colleges, and also our universities are making a creditable effort to meet the situation. The concrete result in trained men will undoubtedly fill all important requirements. But in addition it is reasonable to think that progress in the improvement of the art of Navigation, in this country at least, will be stimulated. Awkward relics of former times may be hurried aside. Such obstacles as the astronomical day may be removed. Certainly beneficial coöperation will follow in greater measure among navigators on vessels of the Navy and the Merchant Marine and those who are experts in related fields on shore.

Ann Arbor, Mich.

WHAT WAS THE STAR OF BETHLEHEM?

STANSBURY HAGAR.

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Annually at midnight on June 21 the festival of the foundation of the temple and of the birth of the new year was repeated. This date marked also the birth of Hathor and of Horus. How was it determined? We know at least that then Spica, the bright star of the Virgin, was setting upon the western horizon just before midnight. That star had been figured in many times and places as the divine celestial mother with the divine child in her arms. The image of Hathor was then carried ot the roof of the temple, there to hold communion with her divine father Ra, the sun god, at the same time that the celestial Virgin was supposed to join the sun in the west. Upon the temple walls Hathor is depicted as the Virgin Mother with the rays of the divine splendor streaming from the circle of her womb and the names of the temple halls and chambers farther indicate their association with a divine birth. Its chief hall is that of the Child in His Cradle, apparently also called the Chapel of the New Year. Around it are the Halls of Birth, Golden Rays, Gold and Frankincense and Incense and the planisphere adds to these hieroglyphs signifying Chamber of Holy Adoration and Palace Chamber of Supreme Light. From this symbolism we may justifiably surmise that the night of the great festival of birth was known as the Holy Night. We know that it was called the Night of the Child in his Cradle.* True this festival seems to invert the solar symbolism by its connection with the summer solstice instead of the winter solstice, but the explanation is quite simple. In rainless Egypt agriculture and life itself depended upon the annual inundation of the Nile, so that there the normal solar seasons were of slight significance and the natural year began, not with the return of the sun, but with the beginning of the rise of the river. This rise reached lower Egypt at about the summer solstice, consequently the Egyptians began their year then and assigned to that date the symbolism of solar birth. The circular planisphere of Denderah was placed within a chamber upon the roof of the Hathor temple, where the priests in quiet and solitude could at any time readily compare its figures with the aspect of the sky. The upper half of the planisphere depicts the zodiac from Libra to Pisces inclusive—exactly the aspect of the summer solstice midnight

* Denderah, Mariette Pacha tome 1. pp. 189, 190.
Wm. M. Adams, The Book of the Master pp. 75, 76.

two milleniums ago. Doubtless the priests memorized this aspect of the planisphere and then determined the date of the birth festival by watching the advance of the zodiacal constellations until the celestial aspect corresponded with that of the planisphere. Thus the stars verified the sacred date for them just as the pole star had verified it for Pepi three milleniums earlier. And as they watched the stars pass on, each to occupy its destined place in the celestial plan, we can understand why they called the temple the Seat of the Heavenly Dances in the Six Heights of Osiris. The writer of the Book of the Master* gives an eloquent description of the scene at the foundation of the temple. He asks us to picture the monarch keeping watch from midnight to midnight upon the sacred design of the heavens. "Then every portion of the celestial surface before him will be divided into groups of stars or constellations corresponding to the sacred images depicted upon the planisphere, and consequently with the various chambers of the temple to which those images themselves correspond. Thus the whole field of the watcher's view would be marked out with precision into well-defined groups or constellations, each represented by its distinctive symbol, immediately recognizable by those, and those alone, who should understand the nature of the temple plan and should be acquainted with the temple structure. And as each midsummer came round, opening a fresh Egyptian year, the hosts of highest heaven gathered around the 'Child in his Cradle', and the festival of the starry universe was fitly celebrated in the temple of Hathor, the Mother of God, herself the 'Habitation' of the holy Light.

"Deeply solemn must have been the scene surrounding the Grand Master, Pepi, on that memorable night when, obedient to the star given command of his long-departed predecessor, he stood and measured the earth. Every feature, every detail, every ornament, speaks with a silent eloquence which echoes through space and time. There lay before the monarch the archaic design, traced out in characters telling of an age already bygone, and, itself new risen from the tomb, giving expression to the eternal destiny of man beyond the grave. In his hand was the Royal 'Khus,' the masonic rule of ancient Egypt. Upon his head sparkled the luminous tiara of Hathor, figuring forth the supernal beauty wherewith the Illuminate should be crowned in the day of immortality. Far in the northern horizon the pole-star shone before his feet, proclaiming the advent of the long-appointed hour. All round, throughout the immensity of the illimitable vault, burned amid the profound stillness of the night the countless multitudes of infinitely distant suns, recalling the sublime passage in the Book of the Master:

* W. M. Adams, London 1898.

'I make the shining circles of the years: and billions are my measurement.' Upward from out the darkling depths of the unfathomable abyss, stretching like boundless wings on either hand, and high aloft by the zenith of the translucent dome, rose, invisible to the common eye but present ever to the mind of the astronomer, the plane of our planet's orbit,—that celestial plane of man's earthly course,—girt by the zodiac, like an azure belt of gleaming gems,

> "Those lights most lustrous of the firmament
> Which through the heaven lead the gliding Year."

Then when the circuit was accomplished, and the surface of the heaven grouped into constellations according to the sacred plan, the monarch gave the signal for laying the foundation of the temple, and, fixing his eyes upon the northern centre of the revolving heaven, commanded the attendant ministers to stretch out the measuring cord in the predetermined direction, which he as Grand Master, and he alone, foreknew."

In the Book of the Dead the soul following the course of the sun exclaims: "I come daily through the house of the god in Lion form and I pass forth from it to the house of Isis, the Mighty, that I may see glorious, mysterious and hidden matters even as she has caused me to see the divine offspring of the Great One."* Recalling the Lion, and the Isis (or Hathor) and Horus of the circular planisphere, this passage seems also to refer to the signs Leo and Virgo with the sun god of the new year located in the latter. The determination of time has now taken a long step forward. It has been surrounded by an elaborate, refined and beautiful ritual and myth interwoven with the arcana of religion and aided by an actual picture of the sky at the critical moment.

The festival of the Virgin Mother and of the Divine Child in His Cradle was not confined to Denderah. It was celebrated at Alexandria and in the Eleusinian Mysteries in Greece at midnight on December 25 in the centuries preceding and following the rise of Christianity. We have a vase painting of the child Liknites exposed to the gaze of the initiates in his mystic cradle or liknon at the festival called Liknophoria. The torches carried by his two attendants signify the night, and the curtain behind him the secrecy of the mysteries. The liknon was a shovel shaped basket used also to carry fruit. Plutarch writes that the Hosioi performed a secret sacrifice in the sacred precinct of Apollo, the sun god, when the Thyiades women raise up Liknites, the Child in the Cradle. This child deity was identified with Dionysus who was slain, dismembered and then reborn, also with the newborn

* Renouf, Book of the Dead, chap. 78 in Pro. So of Bib. Arch., vol. XVI, p. 103.

fruits of the earth as well as with the holy child Brimos, the ear of grain reaped The ceremony of awaking him was connected with solar rebirth and was a mimetic summons to the earth to bring forth her

FIG. 3. THE LIKNOPHORIA RITUAL. J. E. HARRISON.

fruits in due season. A fresh ear of grain recently reaped was shown to the epoptae at Eleusis by night as the supreme revelation and the announcement was made to them: "Holy Brimo has borne a sacred child, Brimos." Brimo is the name of a cereal drink, also a form of the Divine Mother.* We can hardly avoid seeing in these cereal symbols the star Spica, the Sheaf of Wheat, the Celestial Mother, who rose on the eastern horizon exactly at midnight on December 25 and whose rising announced the rebirth of the sun of the new year, lying in his celestial cradle in the zodiac. At Christmas time in the early centuries of our era and probably before, both the Greeks and Saracens celebrated a festival called that of Increasing Light. They ended it at midnight, going into the inmost shrine, whence coming forth they cried, "A virgin hath brought forth a child, the light is about to grow again."† Elsewhere Epiphanius describes in the following words a similar or perhaps identical festival held in the temple of Kore, the celestial Virgin at Alexandria: Having kept watch during the whole night, chanting to the image (of the goddess) with songs and flutes and having brought the night festival to an end with the crowing of the cocks, the torch bearers descend into a subterranean shrine and bring forth a wooden statue (of the goddess) seated in a sedan chair

* Plutarch, De Isis et Osiris, 35; J. E. Harrison, Prolegomena pp. 402, 519, 525, 548-552; Lenormont, Beginnings of History p. 263.

† Epiphanius Schol. Gregor. Bodley 43. Lobeck, Aglaophamus II, 1227, note z.

and having cruciform symbols marked upon her brow, hands and knees. They carried this statue seven times around the midmost temple and then returned it to its subterranean shrine.* Let us observe that this Christmas, birth festival of Increasing Light, evidently refers to the birth of the sun of the new year. And the announcement of the virgin birth at the climax of the ritual is made as exactly as possible at the moment when the celestial Virgin with the Divine Child in her arms rises in the east, a remarkable coincidence if it be such. The nocturnal rites imply the presence of star worship. The "inmost shrine" will suggest the "holy of holies" of the Egyptian temples. In this ritual did not the participants enter the inmost shrine to observe the rising of Spica and having observed it, did they not then announce the virgin birth of the sun of the new year, and having done this did they not carry in procession the image of the celestial virgin Kore in imitation of the passage of Virgo across the sky from the darkness in the east to the darkness in the west?

The cult of the sun god Mithra presents another interesting aspect of the birth festival. This cult is supposed to have originated among the Aryans in or near Persia prior to their separation from the Hindu stock. It became closely related with the cult of Ahura Mazda and Ahriman and the religion of Zoroaster of which the Magi are supposed to have been priests. Spreading westward the Roman soldiers came in contact with it in their oriental campaigns.

Mithra was then known as the invincible god, a title which naturally appealed to them. He became the god of the Roman armies and his cult was quickly spread by them throughout the Empire in the centuries preceding Christianity. It seems indeed strange that so little popular recognition is given to the fact that in the first centuries of our era it had become the dominant religion of the Empire and the principal opponent of Christianity. Thereafter it gradually disappeared before the advance of its younger rival.

The relations between Christianity and Mithraism are most remarkable and mysterious. They have never been satisfactorily explained. Though hostile, many of their most important tenets were held in common so that, from the viewpoint of any other religion, they seem almost like divergent branches of one cult. For example, Mithraism is said to have shared every sacred and fundamental dogma of Christianity and again Tertullian, Jerome and other early fathers of the church assert that Mithraic mysteries were celebrated in the cave in which Christ was born at Bethlehem, "the city of the house of the sun."†

* Epiphanius, Dindorf Ed. 11, 483.

† Dupuis Origins de tous les cultes Tome III, p. 51 ed 4 to Higgins' Anakalypsis Vol. II, p. 99.

Yet there were marked divergences at least exoterically. The basis of Mithraism was frankly symbolic, astronomic and calendric. In his most usual aspect on the monuments Mithra is figured in a cave, mounted upon and slaying a bull while animals below lap the blood that flows from the wounds. On opposite sides of the scene stand two heralds with an upright and an inverted torch respectively. In the corner overhead the sun and moon are represented by two smaller human heads with a halo and a crescent while the signs of the zodiac are arched above the head of the deity. Astronomically the scene undoubtedly represents the sun in the zodiacal sign of the Bull bringing the spring rains and nourishing the crops on which the animals feed. The scorpion directly beneath the bull represents the sign Scorpio in opposition to the sun and demonstrates the basic significance of the picture as reproducing the aspect of the sky at the joyous moment of the vernal equinox. Sometimes two trees further confirm this interpretation, the vernal leaf bearing tree with the bull's head attached being placed opposite the autumnal fruit bearing tree to which a scorpion clings. The heralds typify the morning and evening stars, day and night, summer and winter and in general the alternations of day and night and of the seasons and the passage of time. But who can study the calm serenity of the face of Mithra as sculptured on the bas relief at Petrograd for example, or the passion of the face of the so-called Dying Alexander, now believed to be Mithraic, without perceiving the probability in the whole setting of the scene that behind the seasonal and astronomic symbolism we have a picture of the struggle and triumph of the spiritual self over the physical.

The real name of Mithra, the mediator between God and man, the light that lightest every man that comes into the world, was probably not given except to the initiates of his cult. On the Mithraic monuments we see tablets left blank for the sacred name which is never revealed and then we may wonder if this is the unknown god, the nameless deity of Paul's Athenian inscription. But that is improbable for few Mithraic inscriptions have been found in Greece.

We know little of the myths describing the life of Mithra because apparently they were taught only by word of mouth and in the mysteries, but we can piece together parts of his life story from representations on the monuments. This has been ably done by Professor Franz Cumont. Thus we learn that Mithra was miraculously born from a rock on the banks of a river and under the shade of a sacred tree. Shepherds alone ensconced upon a neighboring mountain where they were tending their flocks, had witnessed the miracle of his entrance into the world and they had drawn near to worship him and to present

the first fruits of their flocks and their harvests.* The scene becomes more interesting to us when we learn that the birthday of Mithra was celebrated on December 25 and it attains a climax when we study it as depicted upon certain Mithraic cameos. On the principal face of one of these Mithra is figured in the center rising from the rock. Over

FIG. 4. MITHRAIC CAMEO. WALSH.

his head are the two stars, Castor and Pollux. Beside him on opposite sides the Dioscuri appear as two crowned kings mounted upon horseback and accompanied by attendants. They have come to worship and have raised their arms in adoration before the new born deity, who himself adores the heavens. It is worthy of note that the heads of the Magian order were always represented as kings, this being an honorary title like the English king at arms.† Two prostrate human figures under the horses may suggest death in contrast with resurrection symbolized by Mithra himself. We know that skeletons were used in the Mithraic ritual. At the top of the scene are the sun and moon and the two birds of day and night. In the center between the sun and moon the eagle holding a serpent in his mouth represents the constellations of Aquila and Serpens, directly opposite Castor and Pollux in the sky. On the left of the lowest line of figures, appearing from behind the mountain of the east, the bread and cup of the Mithraic communion stand for the constellation Crater, the Cup. We are left in no doubt as to the significance of these constellation figures. They are so placed relatively as to reproduce the aspect of the sky just before midnight on December 25, two thousand years ago when Gemini was on the meridian, Aquila on the inferior meridian and Crater rising on the eastern horizon. A star, probably Procyon, is also figured in correct relative position under the left fore-leg of the horse on our left and a dog occupies the position of the constellation of the Greater Dog in the lower right hand portion. The serpent on our left probably represents

* Cumont, The Mysteries of Mithra, pp. 131: 132.

† Higgins' Anakalypsis, Vol. II, p. 98.

Hydra, that on the right possibly Eridanus. At any rate the whole scene is a picture of the sky at or immediately before the moment of the supposed birth of the solar god. We see the time and place of this sacred event marked primarily by the two stars which stand over the generative rock beside the two worshiping kings whose horses evidence that they have come from a distance. This is plainly the Mithraic Nativity and Star of Bethlehem and it is quite possible that the cameo depicts the actual ritual of the festival of birth. It represents a later calendar than that of the Mithraic Bull, so that it must probably be assigned to the later period of Mithraism, possibly post Christian, but whatever its date it is purely Mithraic in character. A similar symbolism is represented upon another cameo.*

We may go much farther afield in both time and place and still find analogies for the story of Bethlehem.

The birth of numerous other deities and personages was announced by a star, for example Yu, founder of the first Chinese dynasty, Lao-tse, inspired sage, Abraham, Aesculapius, Augustus and various other Caesars. According to Jewish legends a star appeared at the birth of Moses and was seen by the Magi of Egypt who informed the king.† In the uranography of ancient China the stars Epsilon, Mu, Nu of Aquarius, through which the sun was actually passing at the time of the winter solstice, were called the House of the Virgin. At this time the asterism presided over the marriage of the principles of light and shade and the union of heaven and earth. The fruit of this marriage was the new light born at the winter solstice apparently a year later. The sign of the celestial Child therefore governed this date and was also known as the Hour or Palace of Generations. So, also, the twelfth moon in January was called the Buds and it was pictured as a newly born infant with its arms raised.‡

The Hindu deity Krishna, the good shepherd, was born among shepherds at midnight in December. A chorus of devatas or angels saluted him with divine hymns and a prophet having examined his stars

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* The first named cameo was originally figured by Walsh, An Essay on Ancient Coins, Medals and Gems, 2nd Edition, London 1830. We have no further information concerning it. Though probably of post Christian date it exhibits no Christian influence. Cumont, our best authority on Mithra, regards it as unquestionably Mithraic, and as referring to the Mithraic birth accompanied by the Dioscuri, the Eucharist and other symbols of the cult. The present writer is responsible for the remainder of the description.

See Cumont, Textes et Monuments Figures Relatifs aux Mysteres de Mithra p. 450. The Mysteries of Mithra pp. 124: 185.

† A. D. White, A History of the Warfare of Science, Vol. 1, p. 172.

‡ Schlegel, Uranographie Chinoise, pp. 48, 50, 64.

declared him to be of celestial descent and visited his father and mother at Gokul. Soon after his birth he was carried away by night and concealed in a remote regoin for fear of a tyrant, whose destroyer it was foretold he would become and who had, for that reason, ordered all male children born at that period to be slain. This story is the subject of an immense sculpture in a cave at Elephanta the date of which, according to Higgins, is at least several centuries prior to the time of Christ.* While some doubt may exist, however, as to the priority of this birth legend and of its freedom from Christian influence there is no question as to the priority of the Budhistic legends. Budha was born at midnight on December 25, of the virgin Maya. When residing in the fourth heaven, astronomic signs and the appearance of a Messianic star announced to him that the time had come for his reincarnation upon earth. His birth was heralded by a supernatural light. Then the Rishis and Devas, the spiritually advanced beings who dwelt upon earth, exclaimed with great joy: "This day Budha is born for the good of men, to dispel the darkness of their ignorance." Then the four heavenly kings took up the strain and the gods of the thirty-three heavens sang: "Today Bodhisatwa is born on earth to give joy and peace to men."† At the time of his birth the constellation Pushya (Flower-Cancer) descending, waited in the rear of the other stars.‡ A Chinese version states that the time of his incarnation was marked by the conjunction of the constellation Kwei ($\gamma\delta\epsilon\theta$ Cancris) with the sun. Ornaments to be presented to him were made when the constellation Chin was setting and Koh (α and ξ Virginis) coming on. As was predicted his mother was on a journey at the time of his birth, and at this time a saint descended from heaven to journey to the child.¶ Zoroaster is said to have predicted that a sacred personage would issue from the womb of an immaculate virgin and that his coming would be preceded by a brilliant star whose light would guide those who sought him to the place of his birth. Plato said that three Magi came to Socrates at his birth bringing gold, frankincense and myrrh.‖

[*To be Continued.*]

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* Higgins, Anakalypsis, Vol. I, pp. 129, 130.

† Bunsen, Angel Messiah, pp 25, 33, 35.

‡ Sacred Books of the East, Vol. X Sutta Niphata, p. 19.

¶ The Romantic Legend of Sakya Buddha, Samuel Beal, London, 1875, pp. 32, 56, 64 et seq.

‖ Higgins, Vol. I, p. 96.

THE ZENITH EQUATORIAL.

WILLIAM H. PICKERING.

The object of this instrument is to enable the observer, with the minimum of effort, to recognize at a glance the quality of the seeing. The astronomer who specializes on work requiring the very highest grade of definition, such as that relating to the surfaces of the Moon and planets, will even in favorable localities often find, after he has gone to the trouble of opening his dome and getting ready for the night's observations, that the seeing is so poor that it is impossible to work to advantage. If he has got up and dressed in the middle of the night or early morning hours, in order to make these particular observations, the case is especially trying. To meet such a case the Zenith Equatorial has been devised, which may be described as a small telescope so mounted as to be opened, used, and closed from a warm room, with the least possible inconvenience, and in the minimum of time.

Even with a lens as small as of 3.5 inches aperture any grade of seeing up to number 10 can be recorded, and that is good enough to undertake any class of observations, even with the largest telescope, and is indeed better than is usually secured in the temperate zones. The mounting must of course be equatorial, and since it is to be used from a closed room an outside mirror is necessary. This will at the same time have the advantage that it permits the observer to stand in a fixed position.

The simplest and best arrangement is to have the tube rotate in bearings about is own axis, and have it pointed towards the south pole. The length of the mirror should be a little more than twice the diameter of the objective, which is placed at the lower end, and the light from it is reflected up the tube to the eyepiece, which must be mounted inside the upper bearing. This bearing is made extra large for the purpose. The hour angle is measured by an index at the eyepiece, and the mirror is turned in declination by a wheel or lever, which transmits the motion through a chain or link to a similar wheel or lever attached directly to the mirror. It is absolutely necessary even with a small objective to have the mirror optically ground. The instrument thus described must of course be mounted on the southern side of the house, the lower end being supported on a masonry pier.

In my own case it was much more convenient to use the northern side of the house, and being in a low latitude this was possible, although the area of the sky available for observation was thereby considerably restricted. The whole of the mounting is made of wood, the thrust being taken up by a glass marble turning on a brass plate. The declination motion is transmitted by four wooded links, two on each side. I use a 2-inch and a ¼-inch eyepiece mounted side by side in the same wooden slide, and properly adjusted as to focus, so that when the slide is in one position the 2-inch serves as a finder, and when in the other the ¼-inch serves to examine the image of the star. The instrument passes through a hole in the wall of the room, and the outer portion is covered by a sliding roof, the tracks being inclined at an angle of 10°.

The apparatus is represented diagramatically in Figure 1, where the sliding roof A B C D rolls on the tracks F G, being drawn up by a rope R passing through the wall of the house W, and thence over two pulleys to a counterpoise. The outer ends of the tracks are supported on the

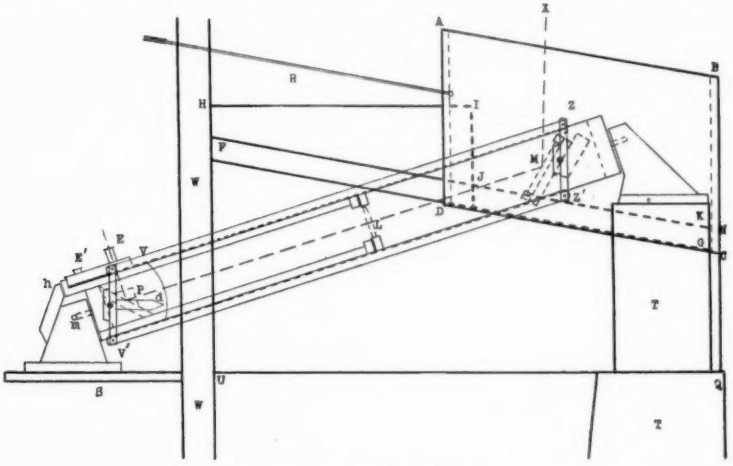

FIGURE 1. THE ZENITH EQUATORIAL.

concrete pier T T. The fixed roof and building are indicated by the letters H I J K B N Q U H, and a passage through which one may walk passes between the wall and the pier, under the fixed structure. The light from the star X falls on the mirror M, is reflected through the lens L to the prism P by which it is reflected up through the low power eyepiece E. The high power eyepiece is shown at E′. The square wooden tube of the telescope is open at the top and bottom, between the lens and the upper bearing. The lens is adjusted by wood screws pressing

against brass plates. It is reached from below. The prism P may be removed and cleaned from above. The lower bearing is supported on the shelf S and the hour angle read by means of the index *h* attached to it. The declination index *d* is attached to the link motion V Z, V′ Z′, which serves to move the mirror. The focus of the high power eyepiece, which must not exceed one quarter of an inch, is adjusted by inserting strips of card beneath the wooden slide which supports it.

A list of fourteen bright stars fairly uniformly spaced was prepared, lying between $\delta + 5°$ and $+ 30°$, and none fainter that 2.6 magnitude. No two of them are separated by a greater distance in right ascension than $2^h\ 30^m$. Therefore one of them is always within 20° of the zenith. These serve, by means of the Standard Scale* to determine the quality of the Seeing, and it is found in practice that after turning on the electric light, the time required to open the shelter, find the star, judge and record the seeing, close the shelter and put out the light, is usually about three minutes.

My objective, which is an old one, is not of very good figure, showing, after it has been properly centered, three irregularly arranged rays, which revolve when the lens is turned about its axis. It is doubtless owing to this fact, that for the same grade of seeing, the appearance of the star images is not quite the same as it is with the excellent 11-inch, and the 3-inch finder, when they are corrected for aperture. It was necessary therefore to determine with this lens the appearance of the image when the various grades of seeing, as determined with the more perfect ones, were presented. Since it is likely that other observers may have small inferior lenses which they sometimes use, and as my scale may be applicable to their instruments, I have thought it worth while to give it below. It must be remembered however that with a ¼-inch eyepiece, diffraction arcs are seen with any lens, in almost any kind of seeing, if the image is far from the axis of the objective. The lens must therefore be carefully centered, and the appearance of the star recorded only when it is passing through the center of the field. Otherwise the results will be wholly fallacious.

Scale of Seeing for an Inferior Lens.

4. Disk large, flickering, irregular, and confused with surrounding detail. Detail blurred and flickering.

5. Disk hazy and confused with detail, the latter blurred.

6. Disk visible, and distinct from detail half the time. The detail is sometimes sharp.

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* Harvard Annals **61** 13. Report on Mars No. 9, Popular Astronomy 1915, **23**, 286.

7. Disk visible nearly or quite all the time, detail sharp.
8. Rings in motion are seen half the time.
9. Rings in motion are constantly seen.
10. Rings stationary or in a very slow motion constantly seen.

Short moving diffraction arcs are occasionally visible even when the seeing is as bad as 4. It is only in connection with hurricanes, or at very low altitudes, that our seeing ever reaches 3, and numbers 1 and 2 are never produced here. It is therefore impossible to describe them, but they are frequently found in connection with clear frosty nights in the temperate zone, and doubtless the description of them given in the Standard Scale would apply equally well to their appearance as seen with a somewhat inferior objective.

In practice we rarely turn the 11-inch telescope on Mars, or the Moon, and never on Jupiter's satellites, unless the Zenith Equatorial shows the stellar disk to be sharp and distinct from the detail, quality 7. Quality 6 might occasionally be accepted if some conspicuous change of appearance were expected to occur, but only meagre results would be anticipated under such conditions.

Mandeville, Jamaica, B. W. I.
Feb. 5. 1918.

DAYLIGHT SEEING.

WILLIAM H. PICKERING

As a result of correspondence with some astronomers who were interested in observing the Sun, it occurred to the writer that it would be desirable if possible to prepare a separate Scale of Seeing which should be applicable to daylight observations. At present there is no generally recognized scale suitable for this class of work, each astronomer estimating the quality according to his own personal impressions. There is therefore no means of properly comparing the seeing at one season of the year with that at another, or of determining whether the conditions at a proposed location are better or inferior to those at already established stations.

The Zenith Equatorial is so convenient an instrument to handle, that it seemed to be the ideal device with which to undertake an investigation of this sort. It was soon found with it that the stars are not

readily available as standards, since even the brighter ones are difficult to find, when viewed in a silvered mirror, and only Arcturus will show the diffraction arcs by daylight. The outer detail on which we depend in the case of the Standard Scale is in general not visible.

The Moon can only be used to advantage between the third and first quarters, and it is then so faint that the identification of the smaller objects on its surface is extremely difficult. Jupiter can be readily found, but is well seen by daylight for only half the year, and is also extremely faint. There remains then only one available object,—the planet Venus, but it can be seen practically throughout the year, and is so bright that it is always conspicuous in the telescope. We began an investigation of its appearance this past January, employing our ¼-inch eyepiece. Comparisons were also made with the appearance of the planet in our 11-inch telescope and 3-inch finder. From these observations a Daylight Scale of Seeing has been constructed. It was immediately found that, unlike the Standard Scale, it was affected but little by the aperture of the instrument employed. Indeed the 11-inch gave if anything rather better definition than the smaller instruments. While the latter usually gave faint supplementary images, which had they moved with sufficient rapidity would have given the effect of a blur, in the 11-inch the blur was the only effect perceived. Usually the seeing was marked the same in both the 11-inch and the finder, but the latter was found to give the more certain result, that is to say the scale divisions were more sharply defined with it. After several weeks of investigation it has been decided to define the divisions of the Daylight Scale of Seeing as follows:—

1. A constantly wavering image.
2. Limb hazy. Bright supplementary images and blur constantly visible.
3. Limb hazy half the time. Faint supplementary images and blur constantly visible.
4. Limb sharp. Faint blur visible half the time or more.
5. Limb sharp. Faint blur only occasionally visible.

The distance of the supplementary images outside the limb generally lies between 1″.5 and 4″. In a limb described as sharp, the breadth of the blur should not exced 0″.3, if somewhat blurred 0″.7. These small angles were measured by comparing them with pencil lines drawn upon a sheet of paper placed some twenty inches from that eye which was not used in making the observations. The diameter of the planet was found to be five-eights of an inch when its angular diameter was 55″. This gave a magnification of 118. The result previously secured from measurements of the foci of the lenses was 120, which

gave a satisfactory check on the method. When the crescent is narrow, which is the case for only about a month in eyery two years, the breadth of the ends of the cusps can be measured. It is found that 0″.3 is about the limiting breadth for a lens of 3.5 inches aperture. In general it may be said that the five numbers of the Daylight Scale indicate possibly a little better seeing than the corresponding ones of the Standard.

It was not found posible in January to examine the planet with the Zenith Equatorial until after noon. The seeing, as was to be expected, gradually improved as the day wore on, until the planet was some 20° above the horizon, when a series of small waves usually appeared along the limb, which previously was perfectly sharp and smooth. Soon after colors due to atmospheric refraction appeared. As a general thing in the daytime our seeing is 3 and 4 as determined by the Zenith Equatorial, and varies but little from day to day, but curiously enough it is appreciably better as measured with the 3-inch finder. This is attributed to the fact that with the former instrument the light, previously to reaching the mirror, passes a few feet above the roof of the house. Although we employ no artificial heat, and there is no means whatever of warming the house, even if we desired to do so, yet it is thought that the wooden shingles may be sufficiently warmed by the sun to start air currents, sufficiently pronounced to interfere with the seeing. With the finder and a power of 180 it is nothing at all unusual for Venus to present a perfectly sharp limb, with the Sun one or two hours above the horizon.

When Venus reaches a more northern declination, which will occur in the spring of the present year, it will no longer be affected by radiation from our roof, and it is hoped then to investigate the matter further, and if necessary to change slightly the present scale of Daylight Seeing, which must therefore be considered for the present as merely provisional.

Mandeville, Jamaica, B. W. I.
Feb. 5, 1918.

IN FICKLE APRIL'S FIRMAMENT.

CHARLES NEVERS HOLMES.

The winter stars depart, and one by one
The stars of spring return, once more our Sun
Shines fitfully, and sleeping buds and flowers
Are awakening amid the April showers.

Like a spectacular exhibition of firmamental fireworks, the grand and glorious galaxy of winter's suns and constellations is slowly setting. For what has seemed a long time this grand and glorious galaxy sparkled and scintillated, adorning magnificently our darkened skies, at first in the east, then in the southeast, afterwards in the south and southwest. When clocks were striking the hour of 9 during November and December evenings these splendid stars and constellations were moving slowly towards the south, where the constellation of Eridanus meanders downwards towards its brightest sun-gem Achernar, out of sight below our horizon. Tonight around the hour of 9 the incomparable sun Sirius and the wonderful constellation Orion, with most of winters' glorious galaxy, are about to set in the west. And, around the same hour, we behold some of the suns and constellations of spring rising and ascending in the east.

The glittering and gigantic sun Arcturus is the most conspicuous of the early sky-jewels of spring time. Well indeed may he be called the "harbinger of spring," but he is also a star of winter, summer and autumn. We admire him as he rises during the month of February and we admire him when he is setting during the month of October. Such vastness of size and intensity of fire are suggested by his firmamental appearance that he does not seem to be distant trillions and trillions of miles. Arcturus is associated with the constellation Boötes, gleaming at the bottom, and it is very easy to find him, since the handle of the great Dipper in Ursa Major points always in the general direction of this grand and glittering star. Although this most brilliant sun-jewel of the constellation Boötes appears at first glance to be motionless amid the darkened sky, careful observation reveals after a while that it is really in very rapid motion, a motion hurling it through space with a velocity approximating 90 or more miles per second. Were such a fiery projectile to pass close by us—not to mention striking us—a sun-projectile one thousand times or so larger than our own sun (and our own Sun is about 1,300,000 times as big as our Earth)—we should certainly be scorched and charred, and our tiny planet-home, as well as most of the Solar System, would be overwhelmed and driven from its orbit. However, this catastrophe cannot possibly happen to

us of the present generation—at least from Arcturus—although the destruction of our world by collision with some invading sun is far from an impossibility.

Another first-magnitude sun in fickle April's firmament is Spica—white, sparkling Spica. This beautiful sky-gem is amid the constellation of Virgo, and it scintillates all by itself in a rather lonely way, its position being about as high above the southeastern horizon as Arcturus is above the eastern horizon, when clocks are announcing the hour of 9 during the first week in April. But Spica in these latitudes ascends at her highest point only about one half the distance from the southern horizon to the zenith, whereas Arcturus rises much higher than Spica towards the zenith. Spica is estimated to be very much farther away from us than is Arcturus, perhaps several hundred light-years, and how remote this first magnitude star must be were its rays which reach us tonight first launched from its vast surface about the time when Columbus began his voyage in search of a then unknown land! But sparkling Spica is not at all remote from us when we consider the illimitable Cosmos around us, a Cosmos in which a trillion miles are probably less in diameter than the diameter of a dust-speck floating amid the terrestrial atmosphere.

Forming a sort of star triangle with glittering Arcturus and sparkling Spica, we behold the "Lion's Heart," Regulus, at the bottom of the sickle-like sun-group in Leo. This sun-group is very noticeable, its six stars resembling also a sort of reversed question-mark. Around 9 P. M., during the first week in April, Regulus and his sickle will be found shining just below the zenith, the rest of Leo's constellation extending towards the eastward. Regulus, although called a first-magnitude sun, has only about 1/13th the brightness of Sirius, which is still scintillating splendidly above the southwestern horizon. It lies almost upon the imaginary line of the ecliptic, so that our own sun nearly covers it once a year as he advances along his "highway". After studying Regulus for a while the star-gazer should take a look at the second brightest sun in Leo, at the eastern end of this constellation. This second brightest sun is named Denebola or Deneb, and was considered by astrologers as an unlucky star, just as Regulus was considered to be a very lucky star.

In April's firmament there are two constellations that resemble each other. These two constellations are Draco and Hydra, both being long and irregular in outline and possessing stars of inconspicuous magnitude. Draco (the Dragon) has its tail placed just northward of the great Dipper and its triangular jaws yawn threateningly in the direction of the dim constellation Hercules, not wholly risen above the northeastern horizon. Draco is well known from its possession of the sun Thuban, formerly (some 4000 years ago) our Pole star, a sky position

now held by Polaris of Ursa Minor. Thuban is the third star from the end of Draco's tail, the star at the end of the tail (Lambda) being close to Alpha of the Dipper's pointers. Draco is situated amid the northern part of the dome of night, whereas Hydra (the Sea Serpent) occupies a long tract in the southern part, extending from close above the southeastern horizon to westward of Leo and Regulus. Its most noticeable star is Cor Hydrae (the Heart of Hydra), also called Alphard (the Solitary). This Heart of Hydra is of about second magnitude, and although not at all conspicuous itself is rather noticeable because of the faint other stars in its constellation. The Hydra has another name, the Water-Snake, and it should not be associated with the constellation of Serpens (the Serpent) whose head is just rising above the eastern horizon.

Near the head of the Hydra there is the inconspicuous constellation of Cancer or the Crab, northwest from which twinkle inseparable Castor and Pollux in Gemini. Like Aries, which belongs to another season of the year, Cancer is one of the smallest of zodiacal constellations. Its brightest suns are Acubens, Asellus borealis and Asellus australis, each of which is of about the fourth magnitude. North and northeast of the Hydra's body there shine respectively the constellations of Crater and Corvus. Crater (the Cup), like Corvus (the Crow), although more noticeable than Cancer, is not a conspicuous constellation, its chief gem Alkes being of about the fourth magnitude. Corvus was formerly known as the Raven, and sparkling Spica of Virgo lies just to the eastward of it. Gamma or Gienah is its most noticeable sun, with a brightness of about 2.3 magnitude. Upon the southern side of the constellation Hydra there is a firmamental expanse of darkness until Argo Navis (the Ship Argo) is reached, below which, not visible to us of these latitudes, glitter the Southern Cross and the gigantic sun Canopus.

There are three other constellations which are usually overlooked by most star-gazers. As would be expected, these constellations are very inconspicuous, yet they are a part of April's evening firmament. The first of these is Canes Venatici or the Hunting Dogs, situated between giant Arcturus and the Dipper. It possesses only two suns visible to unassisted eyesight, one of which is a double-star of about the third magnitude. This double star is named Cor Caroli, and is called a double-star because being so far away from us the two stars, seemingly close together, shine like one star, although a telescope reveals two suns, respectively white and blue, of the third and fifth magnitude. Southeast from Cor Caroli there is the second of these three very inconspicuous constellations—Coma Berenices or Berenice's Hair. Of course we need not believe everything that we read or hear, but it is interesting to be told that Berenice's Hair—the beautiful locks which Queen

Berenice sacrificed as a thank-offering for one of her husband's victories, which were afterwards stolen from an Egyptian temple—is actually the Coma Berenices which we see glimmering so dimly between the suns Arcturus and Regulus. However, this is an ancient myth well worth remembering. Finally, there is the very unimportant constellation of Camelopardus or the Giraffe, extending from the neighborhood of the North star to the vicinity of the constellation Perseus. Like Coma Berenices, this sky-domain of Camelopardus is more suited for the telescope than for our natural eyesight.

Merely mentioning the very well known all-year-round constellations of Ursa Major, Ursa Minor, Cassiopeia and Cepheus, and merely referring to the glories of winter's glorious galaxy, now almost setting in the west, let us turn our attention to the northeastern, eastern and southeastern horizons where, around the hour of 9, Hercules, Serpens and Libra are slowly rising to view. Towards the last of April these three constellations will become more noticeable, and they will be followed by Lyra, Cygnus, Ophiuchus, as well as a part of Scorpio. One of these later four constellations—Lyra—possesses the beautiful, brilliant and blue sun-jewel Vega, which is the fourth brightest sun of night shining in either northern or southern firmament, the three most brilliant suns being Sirius, Canopus and Alpha Centauri. Beautiful Vega is, however, more a star of summer than of the springtime. It is indeed one of the three monarch-suns of June, July and August, Arcturus and Antares being the other magnificent suns of summer time.

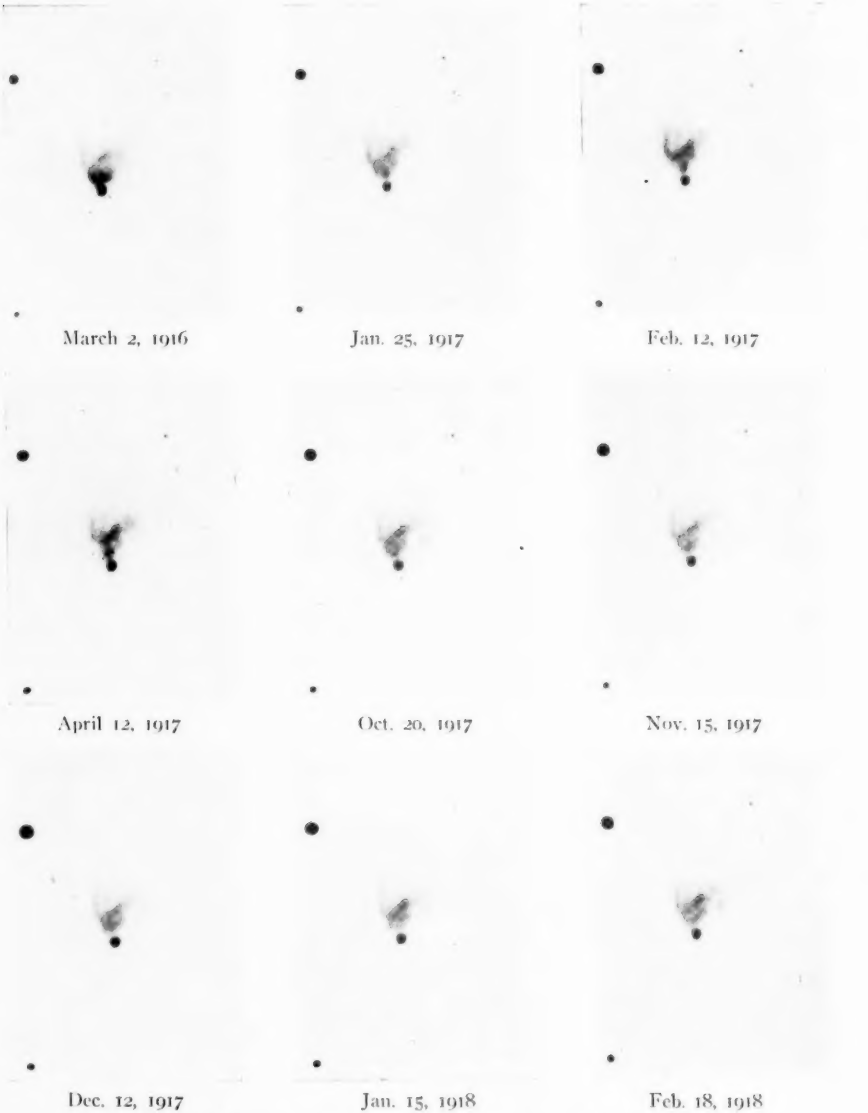
Thus far there has been no mention of the planets, those wanderers across the face of the firmament. As we all know, there are four conspicuous and three less conspicuous satellites of King Sol; Venus, Jupiter, Mars and Saturn, and Mercury, Uranus and Neptune. Mercury is bright and visible at times but he is rather difficult to find. On April 1, white and beautiful Venus rises around half-past 3 in the morning, great and golden Jupiter sets at about 11 in the evening, much discussed and ruddy Mars sets at 5 A.M., and ringed and yellowish Saturn sets at about 3 A.M. As an example of how these four solar satellites change during their wanderings: on April 20, about 3 weeks later, Venus rises at 3:11 A.M., while Jupiter, Mars and Saturn set respectively around 10 P.M., 3:30 A.M., and 2 A.M. Respecting the constellations against whose sparkling backgrounds these four planets are shining, white Venus is in Pisces, golden Jupiter in Taurus, ruddy Mars in Leo-Virgo and yellowish Saturn is in Gemini. Around 9 in the evening during the early part of April, Pisces would not be visible, but Taurus and Gemini are in the west, and Leo-Virgo in the southeast and south. Therefore at that hour Jupiter, Mars and Saturn would be more or less brightly visible.

During April, around the 20th, there is likely to be a fair exhibition of what are popularly called "shooting stars". These "shooting stars" are usually tiny particles, which burning up in our atmosphere produce a little blaze of light, quickly extinguished. Such "stars" may be seen occasionally on any cloudless evening, but they flash more frequently at certain times in the year. Upon April 20 there occurs the exhibition of the Lyrids, named from the fact that these "shooting stars" appear from the firmamental vicinity of the constellation Lyra where the brilliant and beautiful sun Vega is scintillating. As a rule, these minute sky-projectiles are wholly consumed by their violent collision with our atmosphere, but now and then they are larger in bulk, pass through the protecting atmosphere and strike the ground. These fallen aerolites are known as meteors; but where one meteor reaches the terrestrial surface, millions and millions of aerolites are destroyed. It has been estimated that from 16,000,000 to 20,000,000 of these "stars" are burned up by our atmosphere during every 24 hours.

About the same time that the Lyrids are flashing amid the April firmament our sun enters the constellation of Aries. Were we able to see this constellation in daylight, we should behold King Sol begin his firmamental journey across the small domain of Aries, and then watch him advance towards the constellation Taurus. Formerly we spoke of our Sun entering Aries in March instead of in April, but owing to a certain axial motion of our Earth the Sun now enters Aries one month later. Therefore, spring begins when the Sun commences to cross the constellation of Pisces and not when he commences to cross the constellation of Aries. However he is still spoken of as "entering the sign of Aries" at the beginning of spring. During the month of April Sol rises, of course, earlier and earlier every morning, that is, he is ascending day by day higher and higher above the equator. He will continue to ascend higher and higher in the sky until the twenty-second day of June when he enters the constellation of Gemini and summer really commences.

With respect to our Moon in April her last quarter occurs upon the fourth day, the new Moon upon the tenth, her first quarter on the seventeenth and the full Moon upon the twenty-sixth day. These lunar phases are caused, of course, by the position of the Moon relative to the Sun and our Earth, that is, by the amount of sunlight that we can see shining upon the Moon's surface. Just as we are revolving around the Sun so the Moon is revolving around us, and if we observe her for several nights we shall see that at a certain hour she has advanced more and more to the eastward. Finally she disappears below the eastern horizon in full splendor to reappear above the western horizon as a slender crescent of silvery light.

PLATE XI



March 2, 1916 | Jan. 25, 1917 | Feb. 12, 1917

April 12, 1917 | Oct. 20, 1917 | Nov. 15, 1917

Dec. 12, 1917 | Jan. 15, 1918 | Feb. 18, 1918

THE VARIABLE NEBULA IN MONOCEROS, N. G. C. 2261.

Photographed with the 40-inch Lowell Reflector by C. O. Lampland, Lowell Observatory, Flagstaff, Arizona.

The engravers have fallen far short of doing justice to the photographs, much of the fainter detail being lost. The variation in the brighter detail, is however, well shown.

The month of March has passed, the month of April has come again. The glorious galaxy of winter is setting, the suns and constellations of spring are rising. Sirius, Capella and Rigel are descending, Arcturus, Spica and Regulus are ascending. A firmamental transition is in progress, another sidereal season is here. Once more, as the church clocks in city and country are announcing the hour of 9 P. M., the sickle of Regulus sparkles south of the zenith, the great seven-starred Dipper shines south of Polaris, and the Chair of Cassiopeia twinkles northward of the North star. Again April's fickle firmament—sunlighted or star-bespangled—fair or cloudy—is on exhibition for another thirty days and nights.

41 Arlington St.
Newton, Mass.

HUBBLE'S VARIABLE NEBULA IN MONOCEROS, N. G. C. 2261.

C. O. LAMPLAND.

At the request of the editor of POPULAR ASTRONOMY to publish reproductions of Hubble's variable nebula in Monoceros (No. 2261 in Dreyer's New General Catalogue of Nebulae and Clusters of Stars), I am pleased to have the opportunity to show its readers several views of this interesting object. With the 40-inch reflector of the Lowell Observatory I have made in all, beginning in 1916, about 80 photographs of this nebula. I am still occupied in accumulating observational material and no careful and detailed intercomparisons of the photographs have been undertaken. From time to time as the negatives have been made each has in turn been hastily examined in the comparator with several plates of preceding dates so that I have kept myself informed as to the general character and progress of the changes taking place. An exhaustive examination and discussion of this material will probably require considerable time.

It was soon evident that changes in this object were at times rapid and that to follow the variations the photographs should be made at frequent intervals. The exposures have been comparatively short, and for several reasons: it would be possible to follow the changes with greater certainty, especially when the object is low in the morning and evening sky; the brighter parts of the nebula cannot be so well studied when the detail is masked or obscured by too dense a deposit from long exposure; sky conditions at certain seasons often permit

short exposures to be successfully made while long exposures would fail, or at any rate such plates could not be compared with confidence and to the best advantage with other negatives of the series. The most complete set of observations of this object should include long exposures as well as graduated series of shorter exposures. It goes without saying that for photographs of this kind made for intercomparisons great care must be taken with the exposure and development, in addition to the requirements of good definition, so that the negatives shall be of the same intensity for objects in the field that remain constant in brightness.

In the reproductions shown herewith some of the more marked changes should be readily evident, but such a plate can of course give no adequate idea of the remarkable variations revealed by the Blink-Mikroskop of the comparator. With the aid of that instrument slight variations in parts of the nebula have been observed in photographs separated by an interval of only a few days. In examination with the Blink-Mikroskop some of the changes give the impression of being actual displacements of the detail. Whether or not it will be possible to definitely decide that question by careful examination and measurements of the photographs I would not now venture to express an opinion. Many parts of the nebula appear to remain constant in position, form and brightness during the interval covered by the present series of photographs. The nucleus of this nebula, situated at the apex of the comet-shaped nebulosity, is the irregular variable star R *Monocerotis*. In the Harvard Catalogue of Variable Stars its brightness is stated to range from magnitude 9.5 to 13. In the present photographs the star has undergone no very marked fluctuations in its brightness. Until we have learned more about this object it would seem a reasonable supposition to begin with that the variations in the nebulous detail may be ascribed, in part at least, to influences from the variable nucleus. But the striking variations in parts of the nebula as a result of changes of illumination—assuming that the nebulosity is not self-luminous—from the fluctuating brightness of the nucleus may not be entirely obvious. That the nebula shines by reflected light, at any rate the parts that remain constant, seems to be pretty definitely established by Dr. Slipher's observations of the spectrum of the nucleus and the nebulosity —the two appear to be identical. There may be some difficulty in giving a satisfactory explanation for the behavior of the parts of the nebula that undergo in short intervals marked changes of form and brightness, and possibly position. The question might naturally be raised whether we are witnessing actual motion or transference of the nebulous matter, a question we pass without comment at this time. A

careful study of the photographs extending over a sufficiently long interval may furnish us the answer. Some knowledge of the distance of the nebula would be helpful in formulating working hypotheses to explain the observed phenomena.

It may be of some help, in seeking an explanation for the observed rapid variations, to assume that the nucleus is the source of fields of influence (radiations, emissions etc.) not directly perceptible as light—that streams or clouds of charged particles of high velocity, and radiations (electrons etc.) become visible upon encountering in their flight outlying nebulous matter. This line of thought has been suggested by Birkeland's and Störmer's important and beautiful experimental and theoretical investigations relative to the aurora. It may be feasible to test such hypothesis by spectrum observations. From the series of direct photographs it should be possible to locate the temporary bright nebulous detail, and from a comparison of its spectrum with that of the stable nebulosity significant differences might be perceptible.

It will be of interest to learn if there are recurrences of form of the variable nebulous detail.

In addition to the longer exposures for the study of the nebulous detail, very short exposures for magnitude determinations of the nucleus are also frequently made. In the negatives of short exposure the nucleus is pretty small and well defined, but somewhat elongated. In such photographs made under the best conditions, when examined with considerable magnification, there appears to be near the center of the apparent nucleus an extremely small and sharp condensation which is probably the true nucleus.

This object rivals in interest the variable nebula near R *Coronae Australis*. From my photographic observations of the latter nebula with the 40-inch Lowell reflector the southern object appears to be more active, both as to variations of the nebulosity and in the fluctuations of the light of the nucleus. It may be of interest to mention that the same observer, Schmidt of Athens, discovered the variability of both R *Monocerotis* and R *Coronae Australis*. He suspected the variability of the nebulosity near the latter star which was subsequently confirmed by Innes at the Cape and Johannesburg. Interesting observations of it have also been made photographically by H. Knox Shaw at Helwan. With regard to changes in the nebulosity near R *Monocerotis* I have not found any mention, in the literature thus far examined, that any of the earlier observers of this object had suspected its variability until the discovery by Hubble at the Yerkes Observatory. There may be indications in the measure of the position angles of the edges of the nebulosity by earlier visual observers that variations in the form and brightness of the nebula may have influenced the observations.

I have hopes that the series of photographs of these two similar objects may prove mutually helpful in seeking for explanations of the remarkable changes they exhibit.

Lowell Observatory,
Flagstaff, Arizona.
March 20, 1918.

A HOME-MADE TELESCOPE.

VERA M. GUSHEE.

Many who enjoy studying the wonders of the sky would doubtless find telescope-making a most fascinating occupation. Granted that the necessary parts are obtained in advance, it requires no great amount of technical skill or mechanical ingenuity to construct a small, inexpensive telescope well adapted for simple astronomical observations and capable of affording a great deal of pleasure and instruction. Any one who is interested in an experiment of this sort may find explicit directions in the references quoted at the end of this article. The purpose of this paper, which was written during my undergraduate career, is to show how such directions, given largely from a theoretical standpoint, have been worked out in actual practice by a student of first-year astronomy. It was at the end of my beginning course in astronomy that I determined to try my luck at making a telescope. The plan appealed to my younger brother also and he promised to assist in the undertaking. I saw at Smith College Observatory a small home-made telescope with an object-glass one and one-half inches in diameter and of about thirty inches focal length. This was used as a model, with some changes in the details of construction, especially in the style of mounting. Such an instrument, if carefully put together, is almost sure to be a source of great interest and delight for the amateur observer and may even prove useful in at least one field of scientific research, that is, in the observation of variable stars.

The first problem which has to be met when one has such a project in view is the question of obtaining the necessary material with which to work. The lenses are the only parts which cannot be produced by the novice, but since they constitute the one essential feature of a telescope, it is first of all desirable to ascertain how they can be secured. My lenses were purchased from the Scientific Equipment Co., of Brooklyn, New York, at a cost of $2.82 for the set. The tubing which is to be used as a mounting for the lenses can be readily formed by pasting

thick sheets of paper together over a wooden roller. Mailing tubes are just the thing if they can be procured in the right sizes. Five tubes of different dimensions are needed, ranging from the smallest, about an inch in diameter and intended for the eyepiece, to a short tube of larger diameter than the rest, called a dew cap, made to slip over one end of the long main tube so as to protect the object glass when in place. This is the most important of the lenses, since it forms the image of the distant object, which is then magnified by the lenses of the eyepiece.

After ordering the lenses and while awaiting their arrival the tubes were made ready to receive them. First of all, there was the painting, black on the inner, and any desired color on the outer surface. As soon as this was dry they were fitted one into another according to directions. Paper collars were attached to the sheath-tube, which was thus made to fit snugly inside the longer one. Next came the draw-tube, which was covered with velvet so as to slide easily back and forth within the sheath-tube for the purpose of focussing. To the casual observer the telescope might seem complete at this point, but as yet it was only a toy, a "make-believe" affair which would do very well to look *at*, but not to look *through*.

With the arrival of the four precious pieces of glass, which were carefully wrapped in tissue paper and packed in cotton, my enthusiasm for telescopes suddenly increased by leaps and bounds. A description of the lenses will be continued in the following paragraph, which explains how to determine their focal length, a necessary step in the order of procedure.

Although approximate values for the focal length are given in the specifications, they should be determined more exactly for the particular lenses at hand. The method in brief consists in projecting the sun's image, formed by the lens, on a piece of card-board or paper, preferably yellow in color, moving the latter back and forth until the image appears at its brightest and then measuring the distance between the card and lens. When several independent and accordant readings are obtained in this way, the mean of the series gives a satisfactory result.

This experiment proved comparatively simple where the object glass was concerned. This lens, which is one and one-half inches in diameter, has a focal length slightly less than thirty inches. It is composed of two parts loosely fitted together, a double-convex crown-glass lens, and a plano-convex flint-glass lens. Although it has to be handled very cautiously to guard against injuring the highly polished surface, it does not require such delicate measurements as the two smaller lenses for the eyepiece. This is because, when mounted, its distance from the eyepiece may be changed at will by moving the draw-tube in and out

in the process of focussing. But the other lenses had to be permanently mounted with the distance between them equal to one-half the sum of their focal lengths. It seemed wise, therefore, to determine these values with as much precision as possible. The size of these lenses presented a new difficulty. The smallest is not more than one-fourth of an inch in diameter and has a focal length of only three-fourths of an inch, approximately. Some sort of contrivance was necessary to hold the lens and card steady while measurements of its focal length were being made. It would never do to hold them in the fingers, although with an assistant this method worked well enough in the case of the object glass, where less accuracy was required.

In order to provide for this need a simple apparatus was devised consisting of a support for the lens (made of ivory soap), a ruler with a centimeter scale and a piece of card-board with a slit cut into one edge so as to make it slide over the scale. The soap made an excellent holder, for it could be whittled easily into any desired shape so as to sit nicely astride the ruler, while a groove of the right size carved into the top held the lens in a vertical position. With the ruler pointed toward the sun and the card properly adjusted, the distance of the image formed by the lens could be read directly from the scale. A series of readings taken in this way seemed to be quite trustworthy.

And yet was there not some means of verifying these results, which differed in one case by one-fourth of an inch from the value specified for the lens? A distant and prominent object on the earth may serve as well as the sun for an image. We selected a church tower outlined clearly against the sky and most conveniently placed for our purposes. Its image formed on the screen by even the tiniest lens was a perfect miniature representation of the original, only up-side down. Finding the place where it appeared most distinct we noted its distance from the lens which in each case corresponded very closely to the values previously determined. The slight difference in focus for the image of a terrestrial object was inappreciable, as it lay within the unavoidable errors of measurement.

In all these experiments our make-shift apparatus proved so satisfactory that I could not resist substituting a yard stick for the short centimeter scale and testing the object glass by this more convenient and refined method. It is probable, though, as already explained, that so far as the actual construction of the telescope was concerned such precaution was unnecessary.

The next step was to mount the lenses before any thing should happen to them. I gathered from different parts of the house all the necessary paraphernalia and spread it out upon the kitchen table. Besides the lenses and the tubes it consisted of a rather varied assort-

ment, brown paper and tissue paper, an old kid glove, glue, scissors, a sharp knife, blackened card-board, shellac, and wood alcohol. The use of each of these articles will soon become apparent. The tube for the eyepiece had, first of all, to be cut down to the right length, which it will be remembered equals one-half the sum of the focal lengths of the two eye lenses. Two circular diaphragms with holes in the center were made out of the blackened card-board. One of these was glued inside the tube according to directions, to cut off light coming from the edge of the field, the other was used as a mounting for the tiniest lens, which was cemented over the opening. Then this diaphragm and the larger lens were fastened securely one at each end of the tube by means of a little shellac. A strip of tissue paper pasted neatly over the tube and fitted around the edges of the lenses served to hold the parts together, but it was not thick or durable enough to make a suitable covering. The old kid glove was just the thing that was needed. I cut out a good piece of the undressed kid and pasted it smoothly over the paper. This gave the finishing touch to the eye-piece which, it must be confessed, I viewed with considerable satisfaction.

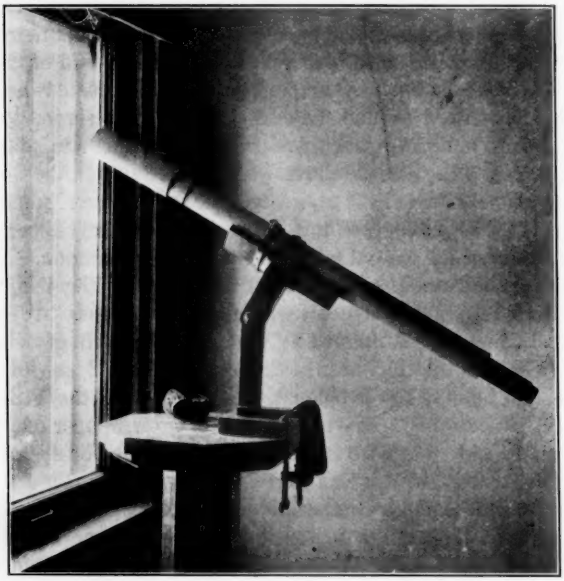
It seemed that now the most painstaking part of the task was completed. But I had not yet dealt with the object glass. At this point the directions read as follows: "Have ready a strip of tissue paper, just the width of the thickness of the lenses at the edges; gum this on one side, and holding the two lenses together, wind the strip around the edges. When this is dry take a strip of brown paper one and one-fourth inches wide and with paste form a short tube or cell around the object glass, using (say) five thicknesses."

Although this sounds comparatively simple, patience and care are also required in large measure, for, in order to keep the lens free from particles of lint and dust and glue, which spreads easily from the inner layer of the cell, I found that it was necessary to follow out the process above described not once only, but many times. So far I have omitted to mention the necessity of cleaning the lenses, but it is an important detail especially in the case of the objective. The smaller lenses were simply dipped in the alcohol and then rubbed with tissue paper before mounting, but the objective requires more careful treatment. To clean this lens wads of cotton soaked in alcohol were pressed gently against the surface *without rubbing* and as before, soft tissue paper was used for drying and polishing.

When the objective, bright and shiny and with no extraneous glue on its surface, was at last provided with a collar of the right thickness, it was carefully inserted into the object end of the telescope at right angles to the sides of the tube. This was first made about two inches shorter than the focal length of the objective so that the image would

fall outside the main tube. A velvet cap was provided later which would slip over the dew-cap and protect the objective when not in use.

The telescope itself was now ready to be mounted, for some sort of support is essential if it is to be used at all advantageously. This part of the instrument, which it fell to my brother's lot to construct, consisted of a neat wooden standard about a foot high and provided with a motion in azimuth and altitude. The telescope lies in a trough-like



MISS GUSHEE'S HOME-MADE TELESCOPE.

arrangement at the top and is held in place with an ordinary strap When it is pointed in any desired direction a turn of the thumb-screw on one side of the support holds it in position, while allowing for a slight motion in order to keep an object in the field of view. The model which was used in making this mounting is described in "Popular Telescopic Astronomy". In many ways it has proved exceptionally convenient. Clamped to a movable stand it may be placed in any desirable spot out-of-doors, or, if the weather is cold and the observer is willing to sacrifice the advantages of being in the open, it may be clamped to a window sill where there is a good view of the objects to be studied.

The day on which our telescope was completed and mounted ready for use, was bright and fair and gave promise of a clear evening. But we did not wait for the sun to sink below the horizon before testing the results of our workmanship. Although the telescope was not meant for terrestrial observations and consequently showed everything inverted, it was possible nevertheless to gain some degree of satisfaction by pointing it toward distant objects on the horizon and noting the sharpness of outline in the images produced as well as the magnifying power of the eyepiece.

By these means my anxiety was partially relieved, but the real test was yet to come; not on that first evening, however, for a thick mist enveloped the sky, so that no satisfactory observing could be done. The next night was favorable. Jupiter shone out clear and bright and I lost no time in directing my "optik tube", not unlike the first which bore that name, toward his shining orb. Soon a large curious disk appeared in the field of view, but where were Galileo's four satellites? Not realizing at first that the focus was entirely wrong, I nevertheless experimented with the draw tube, pushing it in and out until the image became much smaller and brighter and three tiny points of light were revealed, two on one side of the disk and one on the other. The fourth satellite I discovered later, hugging close to the planet's disk and almost hidden in its reflected rays.

The moon, which was in last quarter, rising about ten o'clock in the evening, was to furnish the next most important test. The telescope was already clamped to the window sill on the east side of the house when the edge of the moon appeared above the line of hill tops along the eastern horizon. Very shortly all of the lighted portion was visible and I focussed the telescope upon it. A wealth of detail was immediately disclosed; low level plains contrasted with rugged and broken mountain ridges, and countless circular formations resembling the volcanic craters of the earth, crowded closely together and in places superimposed one upon the other, offering a great variety of detail. Many interesting features stood out boldly along the terminator, which is the boundary between day and night on the moon. Most conspicuous was a long bright line jutting out from the lighted portion into the blackness beyond. It was the chain of the Appenines which still retained the light of the setting sun. One hour sufficed to identify, (with the help of a moon map), over fifteen objects—"seas", mountains and craters—and then the possibilities were far from being exhausted. In fact each observation of the moon taken since that time has revealed new features brought out by closer study, aided by the varying effects of light and shade.

Other more formal tests of the optical properties of a telescope are also desirable. Some of these were made in connection with the preceding observations, others were undertaken as an object in themselves. They have reference to the "squaring" of the objective, spherical and chromatic aberration, magnifying power, and diameter of the field of view.

One of the first tests applied to my small telescope concerned the mounting of the objective. It is important that this lens be set squarely in the main tube, that is, perpendicular to the optical axis, otherwise images which should be round will appear elliptical and wrong impressions will consequently be produced. The test for spherical aberration also has to do with the form of the image. An instrument is defective in this respect if the light, instead of being concentrated into a well-formed image, appears scattered in the field of view. The image of a bright star out of focus should show well defined concentric circles of light. Chromatic aberration, as its derivation indicates, refers to color effects about an image. If the moon is examined through the telescope certain colors will be visible around the edge of the disk; usually blue and orange predominate. These are caused by the unequal refraction of different light rays. This defect, which was very marked in the early telescopes, is for the most part eliminated by the achromatic lens, but not entirely. Even the best lenses produce objectionable colors in some degree but the effect should be at a minimum if the telescope is to be called satisfactory.

All the above tests applied to our little one and one-half inch lens yielded very fair results. The test for spherical aberration was especially favorable, for the image of Arcturus out of focus suggested at once a cross-section of a regular shaped tree trunk where the rings denoting its age show conspicuously.

In order to determine the magnifying power of our telescope, a very simple but entirely satisfactory method is the following: having "set" for infinite focus in advance, that is, having determined at night the position of the draw-tube which produces the best stellar image, we direct the telescope toward the sky in the daytime. Then holding the head at some distance from the eyepiece a small bright circle is seen surrounded by a dark ring. This bright circle, an image of the object glass seen in the eyepiece, is called the emergent pencil of light and its diameter can be easily measured by means of a small instrument called a dynamometer, or a home-made scale such as is described in Byrd's Laboratory Manual, section 20. The magnifying power is found by dividing the diameter of the object glass by the diameter obtained by measurement. Using the latter device I found that the mean of five series of measurements made on five different days gave .068

inches. Combining this with the mean of seven measurements with the dynamometer, my adopted value for the diameter of the emergent pencil of light is .065, which gives for the magnifying power of my telescope 23 diameters.

Another preliminary observation, which is closely related to the preceding, is to determine more exactly the diameter of the field of view in time units which are easily reducible to minutes and seconds of arc. A knowledge of this value is often very helpful in later observations and may be ascertained as follows. A star (preferably near the meridian in the south) is watched as it crosses the field of view and an assistant with a watch notes the instants when the observer calls "time" as the star enters and leaves the field, that is at the beginning and end of the transit. If the star chosen is not on or near the equator, the resulting interval must be reduced to the equator by multiplying the observed time by the cosine of the star's declination. These methods of testing the telescope are typical and not exhaustive. They show what may be done by the person who intends to make the most intelligent use of his instrument.

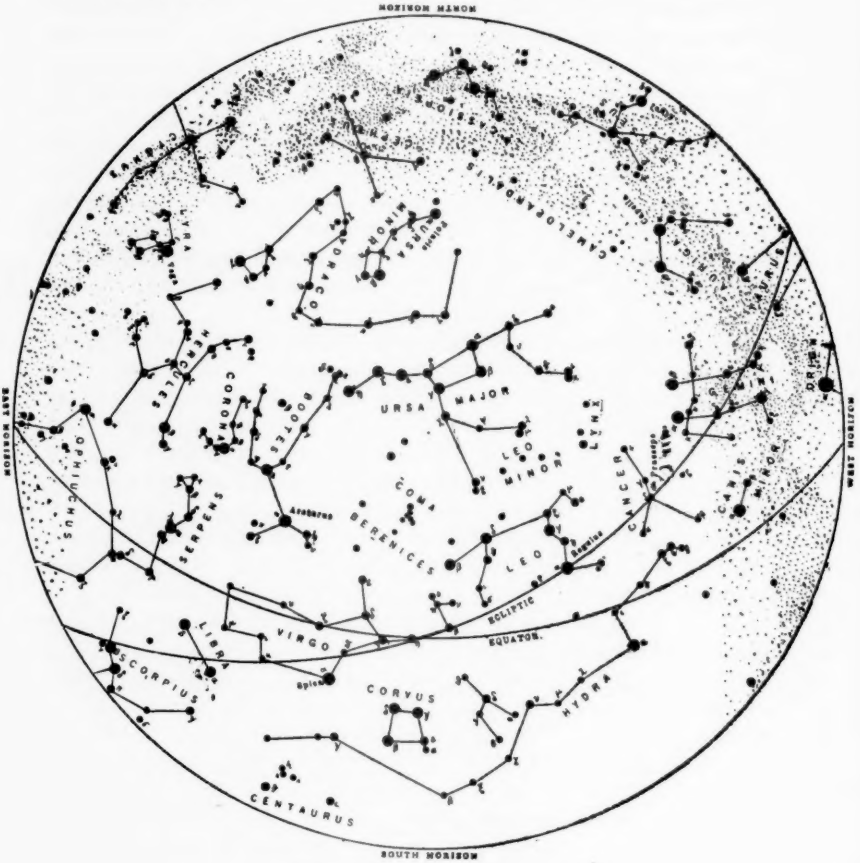
Many of the observations possible for the common two and one-half inch portable telescopes are also well adapted to this less pretentious type of instrument which, though lacking the advantages of a larger objective and more stable mounting, compensates for these deficiencies by offering a simple, effective substitute, easily and quickly handled and therefore more available for use by those who observe for recreation than a larger more elaborately designed model.

The one and one-half inch telescope described represents not more than four dollars in actual cost and a few hours pleasurably and profitably spent. Such an instrument will not only meet the needs of many amateur observers but will prove especially helpful to all who are beginning the study of Astronomy.

References: Byrd's "Laboratory Manual"—Appendix.
Fowler's "Popular Telescopic Astronomy."
Proctor's "Half-hours With a Telescope."
McKready's "Beginners' Star Book."

PLANET NOTES FOR MAY, 1918.

The sun will continue its northeasterly course, and by the end of the month it will be approaching its greatest declination north for the year. It will move from Aries into Taurus, passing between the Pleiades and Aldebaran. At the end of the month it will be about five degrees north of Aldebaran. This interesting portion of the sky will therefore be invisible during this month.



THE CONSTELLATIONS AT 9:00 P. M. MAY 1.

The phases of the moon for this month are as follows:

Last Quarter	May	3 at	4 P.M.	C.S.T.
New Moon		10 "	7 A.M.	"
First Quarter		17 "	2 P.M.	"
Full Moon		25 "	5 P.M.	"

The moon will be nearest the earth for the month on May 8 and farthest from the earth on May 20.

Mercury will begin to be visible on the eastern horizon before sunrise about May 20. On May 24 it will be most easily visible, being on this date at a point of greatest elongation west. It will, however, be about ten degrees south of the sun, and will not rise very long before the sun.

Venus will continue to rise a few hours before the sun, and will be a brilliant morning star during this month. It will be moving eastward a little more rapidly than the sun, and hence will rise later from day to day, and be nearer the horizon at sunrise.

Mars will continue to be one of the principal objects of interest in the sky. It will be on the meridian early in the evening. It will be receding from the earth, and by the end of the month will be at a distance equal to the mean distance of the sun.

Jupiter will be practically invisible, because of nearness to the sun, this month. It will be moving eastward slowly, and the sun will be approaching it in position in the sky.

Saturn will be visible in the western sky during the month. It will cross the meridian about 5 o'clock at the middle of the month.

Uranus will be in quadrature with the sun on May 18. It will then be on the meridian at sunrise, and be visible in the early morning.

Neptune will cross the meridian about five o'clock in the afternoon. It will therefore be visible in the evening during the month. It will be in the constellation Cancer in a region in which there are no bright stars.

Occultations Visible at Washington.

[*From the American Ephemeris.*]

Date 1918	Star's Name	Magnitude	IMMERSION. Washington M.T.	IMMERSION. Angle from N.	EMERSION. Washington M.T.	EMERSION. Angle from N.	Duration
			h m	°	h m	°	h m
May 12	175 H^1 Tauri	6.5	9 02	61	9 41	317	0 39
17	14 Sextantis	6.3	12 27	107	13 23	299	0 55
19	*e* Leonis	5.1	9 30	58	10 06	5	0 36
22	83 Virginis	5.6	7 59	166	8 57	254	0 58
26	39 Ophiuchi	5.1	8 57	150	9 40	226	0 43
26	191 B Ophiuchi	6.3	12 52	105	14 15	248	1 24
26	19 Piscium	4.3	13 40	92	15 05	255	1 25

Satellites of Saturn, May 1918.

[From the *American Ephemeris.*]

CENTRAL STANDARD TIME.

I. Mimas. Period 0^d $22^h.6$.

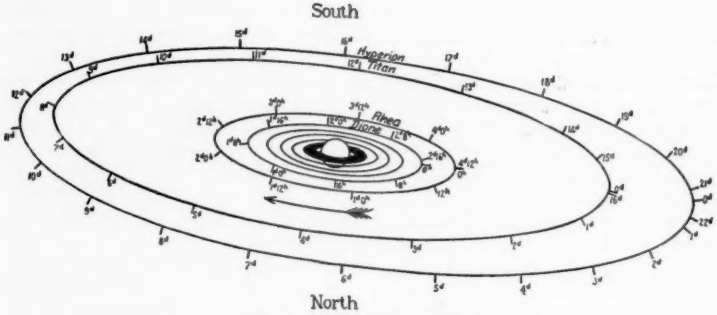
	h		h		h		h	
May 1	10.7 W	May 8	12.3 E	May 16	12.7 W	May 24	12.9 E
2	9.3 W	9	11.0 E	17	11.3 W	25	11.6 E
3	7.9 W	10	9.6 E	18	9.9 W	26	10.2 E
4	6.6 W	11	8.2 E	19	8.5 W	27	8.8 E
7	13.7 E	12	6.8 E	20	7.2 W	28	7.4 E

II. Enceladus. Period 1^d $8^h.9$.

May 0	19.6 E	May 9	1.0 E	May 17	6.3 E	May 25	11.7 E
2	4.5 E	10	9.9 E	18	15.2 E	26	20.6 E
3	13.4 E	11	18.8 E	20	0.1 E	28	5.5 E
4	22.3 E	13	3.7 E	21	9.0 E	29	14.4 E
6	7.2 E	14	12.6 E	22	17.9 E	30	23.3 E
7	16.1 E	15	21.4 E	24	2.8 E		

III. Tethys. Period $1^d\ 21^h.3$.

	h		h		h		h
May 1	3.5 E	May 8	16.8 E	May 16	6.1 E	May 23	19.4 E
3	0.8 E	10	14.1 E	18	3.4 E	25	16.7 E
4	22.2 E	12	11.5 E	20	0.8 E	27	14.1 E
6	19.5 E	14	8.8 E	21	22.1 E	29	11.4 E
						31	8.7 E



SATELLITES OF SATURN, 1918.

Apparent Orbits of the Seven Inner Satellites of Saturn at Date of Opposition, January 31, 1918, as seen in an inverting telescope.

IV. Dione. Period $2^d\ 17^h.7$.

May 3	6.4 E	May 11	11.5 E	May 19	16.7 E	May 27	21.8 E
6	0.1 E	14	5.2 E	22	10.4 E	30	15.6 E
8	17.8 E	16	23.0 E	25	4.1 E		

V. Rhea. Period $4^d\ 12^h.5$.

May 2	6.0 E	May 11	7.0 E	May 20	8.0 E	May 29	9.1 E
6	18.5 E	15	19.5 E	24	20.6 E		

VI. Titan. Period $15^d\ 23^h.3$.

May 0	19.3 E	May 8	12.6 W	May 16	18.9 E	May 24	12.4 W

VII. Hyperion. Period $21^d\ 7^h.6$.

May 0	20.4 W	May 10	20.1 E	May 22	4.6 W

VIII. Iapetus. Period $79^d\ 22^h.1$.

May 3	10.9 E	May 23	14.3 I

IX. Phoebe. Period $523^d\ 15^h.6$.

	α Ph.—α Sat.	δ Ph.—δ Sat.		α Ph.—α Sat.	δ Ph.—δ Sat.
	m s	′ ″		m s	′ ″
May 2	+0 42.0	−4 24	May 16	+1 03.7	−5 29
4	0 45.3	4 34	18	1 06.5	5 37
6	0 48.5	4 44	20	1 09.2	5 45
8	0 51.7	4 53	22	1 11.9	5 53
10	0 54.8	5 02	24	1 14.4	6 01
12	0 57.8	5 11	26	1 16.9	6 08
14	+1 00.8	−5 20	28	1 19.3	6 15
			30	+1 21.6	−6 22

VARIABLE STARS.

Minima of Variable Stars of Short Period.

[Calculated by Julia M. Hawkes and Franz M. Exner at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5h; Central Standard 6h; etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1918 May											
	h m	° ′		d h	d	h	d	h	d	h	d	h	d	h	d	h
SY Androm.	0 08.0	+43 09	9.5—13.0	34 21.8					27	2						
RT Sculptor.	31.5	−26 13	9.6—10.5	0 12.3	2	22;	10	14;	18	6;	25	23				
UU Androm.	38.5	+30 24	10.7—11.9	1 11.7	1	1;	8	11;	23	8;	30	18				
U Cephei	0 53.4	+81 20	7.0— 9.0	2 11.8	1	20;	9	7;	24	6	31	18				
Z Persei	2 33.7	+41 46	9.4—12	3 01.4	5	4;	11	7;	23	12;	29	15				
TW Cassiop.	37.6	+65 19	8.2— 9.0	1 10.3	4	23;	12	3;	19	6;	26	10				
RY Persei	39.0	+47 43	8.0—10.3	6 20.7	3	4;	10	0;	16	21;	23	18				
RZ Cassiop.	39.9	+69 13	6.9— 8.1	1 04.7	4	2;	11	6;	18	10;	25	15				
TX Cassiop.	44.4	+62 22	9.4—10.1	2 22.2	7	16;	16	11;	25	5						
ST Persei	53.7	+38 47	8.5—10.5	2 15.6	7	6;	15	5;	23	4;	31	2				
RX Cassiop.	2 58.8	+67 11	8.6— 9.1	32 07.6							30	11				
Algol	3 01.7	+40 34	2.3— 3.5	2 20.8	5	13;	11	7;	22	18;	28	12				
RT Persei	16.7	+46 12	9.5—11.5	0 20.4	1	12;	8	7;	21	21;	28	17				
λ Tauri	55.1	+12 12	3.3— 4.2	3 22.9	6	7;	14	4;	22	2;	30	0				
RW Tauri	3 57.8	+27 51	7.1—<11	2 18.5	6	1;	14	8;	22	15;	30	23				
RV Persei	4 04.2	+33 59	9.5—11.0	1 23.4	2	3;	10	0;	17	21;	25	19				
RW Persei	13.3	+42 04	8.8—11.0	15 04.8	2	13;	15	18;	28	23						
SZ Tauri	31.4	+18 20	7.2— 7.7	3 03.6	7	10;	16	20;	26	7						
RS Cephei	4 48.6	+80 06	9.5—12.0	12 10.1	9	11			21	21						
TT Aurigae	5 2.80	+39 27	7.8— 8.7	0 16.0	4	1;	10	17;	24	1;	30	17				
RY Aurigae	11.5	+38 13	10.7—11.7	2 17.5	8	19;	17	0;	25	4						
RZ Aurigae	42.9	+31 40	10.6—13.3	3 00.3	5	9;	11	9;	23	10;	29	11				
SV Tauri	45.8	+28 05	9.4—11.0	2 04.0	3	0;	11	16;	20	8;	29	0				
Z Orionis	50.2	+13 40	9.7—10.7	5 04.9	6	5;	16	15;	27	1						
SV Gemin.	54.6	+24 28	9.8—<11	4 00.2	1	19;	9	19;	27	20;	25	20				
RW Gemin.	5 55.4	+23 08	9.5—11.0	2 20.8	1	11;	7	5;	18	16;	30	3				
U Columbae	6 11.2	−33 03	9.2—10.0	2 19.2	1	20;	13	1;	24	6;	29	20				
SX Gemin.	22.0	+20 37	10.8—11.5	1 08.8	4	15;	12	20;	21	1;	29	6				
RW Monoc.	29.3	+ 8 54	9.0—10.8	1 21.7	7	12;	15	3;	22	18;	30	9				
RX Gemin.	43.6	+33 21	8.8— 9.6	12 05.0	3	23;	16	4;	28	9						
RU Monoc.	6 49.4	− 7 28	9.8—10.5	0 21.5	2	6;	9	10;	26	14						
R Can. Maj.	7 14.9	−16 12	5.8— 6.4	1 03.3	7	16;	14	11;	21	7;	28	3				
RY Gemin.	21.7	+15 52	8.9—<10	9 07.2	2	22;	12	5;	21	13;	30	20				
Y Camelop.	27.6	+76 17	9.5—12	3 07.3	6	20;	13	11;	20	2;	26	16				
TX Gemin.	30.3	+17 8	10.0—11.9	2 19.2	7	15;	16	0;	24	10						
RR Puppis	43.5	−41 08	9.4—10.7	6 10.3	1	15;	8	1;	20	22;	27	8				
V Puppis	7 55.4	−48 58	4.1— 4.8	1 10.9	5	2;	12	8;	19	15;	26	21				
X Carinae	8 29.1	−58 53	7.9— 8.7	0 13.0	5	22;	14	1;	22	4;	30	7				
S Cancri	8 38.2	+19 24	8.2—10	9 11.6			10	11;	19	22;	29	10				
RX Hydrae	9 00.8	− 7 52	9.1—10.5	2 6.8	1	14;	8	10;	22	3;	28	23				
S Velorum	29.4	−44 46	7.8— 9.3	5 22.4	6	4;	12	2;	23	23;	29	21				
Y Leonis	9 31.1	+26 41	9.3—11.2	1 16.5	2	15;	9	9;	22	21;	29	14				
RR Velorum	10 17.8	−41 36	10.0—10.9	1 20.5	1	16;	9	2;	23	22;	31	8				
SS Carinae	10 54.2	−61 23	12.2—12.8	3 07.2	5	6;	11	20;	25	1;	31	15				
ST Urs. Maj.	11 22.4	+45 44	6.7— 7.2	8 19.2	8	15;	17	10;	26	5						
RW Urs. Maj.	35.4	+52 34	10.3—11.4	7 07.9	6	20;	14	4;	21	12;	28	19				
Z Draconis	11 39.8	+72 49	9.9—13.6	1 08.6	7	2;	13	21;	20	16;	27	11				
RZ Centauri	12 55.6	−64 05	8.5— 8.9	1 21.0	3	4;	10	16;	18	4;	25	16				
RS Can. Ven.	13 06.3	+36 28	7.5—12.5	4 19.2	3	11;	13	2;	22	16						
SS Centauri	13 07.2	−63 37	8.8—10.4	2 11.5	3	5;	10	16;	18	2;	25	12				
δ Librae	14 55.6	− 8 07	4.8— 6.2	2 07.9	7	6;	14	5;	21	5;	28	4				

Minima of Variable Stars of Short Period—Continued.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1918 May
	h m	° ′		d h	d h d h d h d h
U Coronae	15 14.1	+32 01	7.6— 8.7	3 10.9	5 4; 12 2; 18 23; 25 21
TW Draconis	32.4	+64 14	7.3— 8.9	2 19.3	4 15; 13 1; 21 11; 29 21
SS Librae	15 43.4	−15 14	9.3—11.5	0 18.4	7 14; 15 5; 22 21; 30 13
SW Ophiuchi	16 11.1	− 6 44	9.2—10.0	2 10.7	1 4; 8 12; 23 4; 30 12
SX Ophiuchi	12.6	− 6 25	10.5—11.2	2 01.5	7 6; 15 12; 23 18
R Arae	31.1	−56 48	6.8— 7.9	4 10.2	2 1; 10 22; 19 18; 28 15
TT Herculis	16 49.9	+17 00	8.9— 9.3	20 18.1	9 0; 20 2; 29 18
TU Herculis	17 09.8	+30 50	9.5—12	2 06.4	5 18; 12 13; 19 9; 26 4
U Ophiuchi	11.5	+ 1 19	6.0— 6.7	0 20.1	4 13; 12 22; 21 8; 29 17
u Herculis	13.6	+33 12	4.6— 5.4	2 01.2	1 6; 7 9; 19 17; 25 20
TX Herculis	15.4	+42 00	8.3— 9.0	1 00.7	7 9; 14 14; 21 19; 29 0
RV Ophiuchi	29.8	+ 7 19	9. —12	3 16.5	4 18; 12 3; 19 12; 26 21
SZ Herculis	36.0	+33 01	9.5—10.3	0 19.6	4 12; 12 16; 20 21; 29 1
TX Scorpii	48.6	−34 13	7.5— 8.2	0 22.6	7 5; 14 18; 22 7; 29 19
UX Herculis	49.7	+16 57	8.8—10.5	1 13.2	7 3; 14 20; 22 14; 30 8
Z Herculis	53.6	+15 09	7.1— 7.9	3 23.8	8 16; 16 16; 24 16
WX Sagittae	53.6	−17 24	9.2—10.8	2 03.1	5 9; 13 22; 22 10; 30 23
WY Sagittae	17 54.9	−23 1	9.5—10.6	4 16.0	8 5; 17 3; 26 21
SX Draconis	18 03.0	+58 23	9.3—10.5	5 04.1	8 21; 19 5; 29 13
RS Sagittarii	11.0	−34 08	5.9— 6.3	2 1.00	3 0; 10 6; 17 12; 24 18
V Serpentis	11.1	−15 34	9.5—11.1	3 10.9	2 21; 9 19; 23 15; 30 12
RZ Scuti	21.1	− 9 15	7.4— 8.3	15 03.2	13 15; 28 18
RZ Draconis	21.8	+58 50	9.5—10.2	0 13.2	1 14; 8 18; 15 22; 23 2
RX Herculis	26.0	+12 32	7.0— 7.6	0 21.3	5 23; 13 2; 20 5; 27 7
SX Sagittarii	39.7	−30 36	8.7— 9.8	2 01.8	6 2; 14 9; 22 17; 31 0
RR Draconis	40.8	+62 34	9.3—13	2 19.9	9 10; 17 22; 26 10
RS Scuti	43.7	−10 21	9.3—10.3	0 15.9	1 17; 8 8; 15 0; 21 15
β Lyrae	46.4	+33 15	3.4— 4.1	12 21.8	7 18; 20 16
U Scuti	18 48.9	−12 44	9.1— 9.6	0 22.9	7 11; 15 2; 22 18; 30 9
RX Draconis	19 01.1	+58 35	9.3—10.2	1 21.4	2 15; 10 5; 17 18; 25 8
RV Lyrae	12.5	+32 15	11. —12.8	3 14.4	4 22; 12 3; 19 8; 26 12
RS Vulpec.	13.4	+22 16	6.9— 8.0	4 11.4	2 16; 11 14; 20 13; 29 12
U Sagittae	14.4	+19 26	6.5— 9.0	3 09.1	7 7; 14 1; 20 19; 27 13
Z Vulpec.	17.5	+25 23	7.3— 8.5	2 10.9	5 19; 13 4; 20 13; 27 21
TT Lyrae	24.3	+41 30	9.3—11.6	5 05.8	1 5; 11 17; 22 4; 27 10
UZ Draconis	26.1	+68 44	9.0— 9.8	1 15.1	1 9; 7 22; 20 23; 27 11
SY Cygni	19 42.7	+32 28	10 —12	6 00.2	6 6; 12 7; 24 7; 30 7
WW Cygni	20 00.6	+41 18	9.3—13.4	3 07.6	1 16; 8 8; 21 14; 28 5
SW Cygni	03.8	+46 01	9. —11.7	4 13.8	1 1; 10 4; 19 8; 28 11
VW Cygni	11.4	+34 12	9.8—11.8	8 10.3	4 18; 13 4; 21 14; 30 1
RW Capric.	12.2	−17 59	8.8—10.6	3 09.4	5 14; 12 9; 19 4; 25 23
UW Cygni	19.6	+42 55	10.5—10.8	3 10.8	5 5; 12 3; 19 1; 25 22
V Vulpec.	32.3	+26 15	8.2—9.8	37 19.0	25 19;
W Delphini	33.1	+17 56	9.4—12.1	4 19.4	2 5; 11 20; 21 10; 31 1
RR Delphini	38.9	+13 35	10.5—11.8	4 14.4	6 6; 15 11; 24 16
Y Cygni	48.1	+34 17	7.1— 7.9	1 12.0	4 3; 11 15; 19 3; 26 14
WZ Cygni	49.3	+38 27	9.9—10.8	0 14.0	3 12; 11 2; 18 17; 26 7
RR Vulpec.	20 50.5	+27 32	9.6—11.0	5 01.2	7 15; 17 18; 27 20
VV Cygni	21 02.3	+45 23	12.1—13.8	1 11.4	2 12; 9 21; 17 7; 24 16
AE Cygni	09.0	+30 20	10.8—11.4	0 23.3	9 2; 18 19; 28 12
RY Aquarii	14.8	−11 14	8.8—10.4	1 23.2	1 9; 9 6; 17 3; 25 0
RT Lacertae	21 57.4	+43 24	9.1—10.5	5 01.7	3 7; 13 11; 23 14
UZ Cygni	55.2	+43 52	8.9—11.6	31 07.3	8 19
RW Lacertae	22 40.6	+49 08	10.2—11.2	5 04.4	2 11; 12 20; 23 5; 28 9
TT Androm.	23 08.7	+45 36	11.3—12.6	2 18.3	5 21; 14 4; 22 11; 30 18
Y Piscium	29.3	+ 7 22	9.0—12.0	3 18.4	4 7; 11 20; 19 9; 26 22
TW Androm.	23 58.2	+32 17	8.6—11.5	4 02.9	6 18; 15 0; 23 6; 31 12

Maxima of Variable Stars of Short Period.

[Calculated by Julia M. Hawkes at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time. To obtain Eastern standard time subtract 5h; Central standard time 6h; etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1918. May
	h m	° ′		d h	d h d h d h d h
SX Cassiop.	0 05.5	+54 20	8.6— 9.2	36 13.7	1 3
SY Cassiop.	0 09.8	+57 52	9.3— 9.9	4 1.7	7 0; 15 4; 23 7; 31 10
RR Ceti	1 27.0	+ 0 50	8.3— 9.0	0 13.3	5 22; 13 16; 21 9; 29 3
RW Cassiop.	1 30.7	+57 15	8.9—11.0	14 19.2	10 2; 25 7
V Arietis	2 09.6	+11 46	8.3— 9.0	0 23.8	4 23; 12 22; 20 20; 28 19
SU Cassiop.	2 43.0	+68 28	6.5— 7.0	1 22.8	5 8; 13 3; 20 22; 28 17
TU Persei	3 01.8	+52 49	11.4—12.2	0 14.6	4 4; 11 11; 18 18; 26 1
RW Camelop.	3 46.2	+58 21	8.2— 9.4	16 00.0	15 31
SX Persei	4 10.2	+41 27	10.4—11.2	4 07.0	1 4; 9 18; 18 8; 26 22
SV Persei	42.8	+42 07	8.8— 9.6	11 03.1	11 22; 23 1
RX Aurigae	4 54.5	+39 49	7.2— 8.1	11 15.0	8 1; 19 16; 31 7
SX Aurigae	5 04.6	+42 02	8.0— 8.7	1 12.8	6 18; 14 10; 22 2; 29 18
SY Aurigae	05.5	+42 41	8.4— 9.5	10 03.3	1 21; 12 0; 22 3
Y Aurigae	21.5	+42 21	8.6— 9.6	3 20.6	4 13; 12 6; 19 23; 27 16
RZ Gemin.	5 56.6	+22 15	9.1—10.0	5 12.7	5 11; 10 23; 22 1; 27 13
RS Orionis	6 16.5	+14 44	8.2— 8.9	7 13.6	3 10; 10 23; 18 13; 26 2
T Monoc.	19.8	+ 7 08	5.7— 6.8	27 00.3	21 2
RT Aurigae	23.0	+30 33	5.1— 6.0	3 17.5	7 17; 15 4; 22 15; 30 1
RZ Camelop.	23.7	+67 06	11.0—13.0	0 11.5	1 22; 9 3; 23 13; 30 18
W Gemin.	29.2	+15 24	6.7— 7.5	7 22.0	6 16; 14 14; 22 12; 30 10
ζ Gemin.	6 58.2	+20 43	3.7— 4.3	10 03.7	4 10; 14 14; 24 18
RU Camelop.	7 10.9	+69 51	8.5— 9.8	12 06.5	3 16 25 23
RR Gemin.	7 15.2	+31 04	10.0—11.5	0 09.5	3 20; 11 19; 19 18; 27 16
V Carinae	8 26.7	−59 47	7.4— 8.1	6 16.7	1 4; 7 21; 21 7; 27 23
T Velorum	8 34.4	−47 01	7.6— 8.5	4 15.3	7 19; 17 2; 26 8
V Velorum	9 19.2	−55 32	7.5— 8.2	4 08.9	3 21; 12 14; 21 8; 30 2
RR Leonis	10 02.1	+24 29	9.1—10.1	0 10.9	4 23; 11 17; 18 12; 25 7
SU Draconis	11 32.2	+67 53	8.9— 9.6	0 15.8	4 0; 10 15; 23 20; 30 10
S Muscae	12 07.4	−69 36	6.4— 7.3	9 15.8	7 12; 17 3; 26 19
SW Draconis	12.8	+70 04	8.8— 9.6	0 13.7	1 8; 9 8; 17 7; 25 7
T Crucis	15.9	−61 44	6.8— 7.6	6 17.6	6 3; 12 21; 19 14; 26 8
R Crucis	18.1	−61 04	6.8— 7.9	5 19.8	6 3; 11 23; 23 15; 29 11
S Crucis	12 48.4	−57 53	6.5— 7.6	4 16.6	5 9; 14 19; 24 4; 28 20
W Virginis	13 20.9	− 2 52	8.7—10.4	17 06.5	9 18 27 1
SS Hydrae	25.0	−23 08	7.4— 8.1	8 4.8	2 15; 10 20; 19 0; 27 5
RV Urs. Maj.	13 29.4	+54 31	9.2— 9.9	0 11.2	1 21; 8 22 22 23; 29 23
ST Virginis	14 22.5	− 0 27	10.3—11.4	0 09.9	1 1; 9 6; 17 11; 25 16
V Centauri	25.4	−56 27	6.4— 7.8	5 11.9	3 3; 8 15; 19 15; 30 15
RS Bootis	29.3	+32 11	8.6—10.0	0 09.1	7 20; 15 9; 22 23; 30 12
RU Bootis	14 41.5	+23 44	12.8—14.3	0 11.9	6 14; 14 0; 21 10; 28 20
R Triang. Austr.	15 10.8	−66 08	6.7— 7.4	3 09.3	4 22; 11 17; 18 12; 25 6
S Triang. Austr.	15 52.2	−63 29	6.4— 7.4	6 07.8	5 14; 11 22; 24 13; 30 21
S Normae	16 10.6	−57 39	6.6— 7.6	9 18.1	5 16; 15 10; 25 4
RW Draconis	33.7	+58 03	9.6—10.8	0 10.6	7 12; 16 8; 25 5
RV Scorpii	16 51.8	−33 27	6.7— 7.4	6 01.5	4 17; 10 18; 22 21; 28 23
X Sagittarii	17 41.3	−27 48	4.4— 5.0	7 00.3	2 5; 9 6; 23 6; 30 7
Y Ophiuchi	47.3	− 6 07	6.1— 6.5	17 02.9	9 2 26 5
W Sagittarii	17 58.6	−29 35	4.3— 5.1	7 14.3	8 1; 15 15; 23 5; 30 20
Y Sagittarii	18 15.5	−18 54	5.4— 6.2	5 18.6	2 3; 7 22; 19 11; 25 5
U Sagittarii	26.0	−19 12	6.5— 7.3	6 17.9	6 6; 13 0; 19 18; 26 12
Y Scuti	32.6	− 8 27	8.7— 9.2	10 08.3	4 10; 14 18; 25 2
Y Lyrae	34.2	+43 52	11.3—12.3	0 12.1	6 4; 12 5; 24 6; 30 7

Maxima of Variable Stars of Short Period—Continued.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1918. May					
	h m	° ′		d h	d h	d h	d h	d h	d h	d h
RZ Lyrae	18 39.9	+32 42	9.9—11.2	0 12.3	6 8;	12 12;	24 18;	30 12		
RT Scuti	44.1	−10 30	9.1— 9.7	0 11.9	5 23;	11 22;	23 19;	29 18		
κ Pavonis	18 46.6	—67 22	3.8— 5.2	9 02.2	6 18;	15 20;	24 23			
U Aquilae	19 24.0	− 7 15	6.2— 6.9	7 00.6	3 15;	10 15;	24 16;	31 17		
XZ Cygni	30.4	+56 10	8.6— 9.3	0 11.2	1 1;	8 1;	22 1;	29 1		
U Vulpec.	32.2	+20 07	6.5— 7.6	7 23.5	3 11;	11 11;	19 10;	27 10		
SU Cygni	40.8	+29 01	6.2— 7.0	3 20.3	3 4;	10 20;	18 13;	26 5		
η Aquilae	47.4	+ 0 45	3.7— 4.5	7 04.2	2 13;	9 17;	24 2;	31 6		
S Sagittae	51.5	+16 22	5.6— 6.4	8 09.2	9 7;	17 17;	26 2			
X Vulpec.	19 53.3	+26 17	9.51—0.5	6 07.7	2 18;	9 2;	21 17;	28 1		
X Cygni	20 39.5	+35 14	6.0— 7.0	16 09.3		12 0		28 10		
T Vulpec.	47.2	+27 52	5.5— 6.1	4 10.5	4 13;	13 10;	22 7;	31 3		
WY Cygni	52.3	+30 03	9.6—10.4	0 13.5	6 13;	13 7;	20 0;	26 18		
RV Capric.	55.9	−15 37	9.2—10.1	0 10.7	4 4;	10 21;	24 7;	31 1		
TX Cygni	20 56.4	+42 12	8.5— 9.7	14 17.4		11 19		26 13		
VY Cygni	21 00.4	+39 34	8.8— 9.5	7 20.6	1 6;	9 2;	16 23;	24 20		
SW Aquarii	10.2	— 0 20	9.9—10.8	0 11.0	4 20;	11 17;	18 15;	25 12		
VZ Cygni	21 47.7	+42 40	8.2— 9.2	4 20.7	2 6;	12 0;	21 17;	31 11		
Y Lacertae	22 05.2	+50 33	9.1— 9.6	4 07.8	2 6;	10 21;	19 13;	28 5		
δ Cephei	25.5	+57 54	3.7— 4.6	5 08.8	1 13;	12 7;	23 0;	28 9		
Z Lacertae	36.9	+56 18	8.2— 9.0	10 21.1	3 10;	14 13;	25 11			
RR Lacertae	37.5	+55 55	8.5— 9.2	6 10.1	6 12;	12 22;	19 8;	25 18		
V Lacertae	22 44.5	+55 48	8.5— 9.5	4 23.6	5 21;	10 21;	20 20;	30 19		
X Lacertae	45.0	+55 54	8.2— 8.6	5 10.7	2 0;	12 21;	23 18;	29 5		
SW Cassiop.	23 03.7	+58 11	9.2— 9.7	5 10.6	1 3;	6 13;	17 11;	28 8		
RS Cassiop.	32.6	+61 52	9.0—11.0	6 07.1	1 4;	7 11;	20 2;	26 9		
RY Cassiop.	47.2	+58 11	9.3—11.8	12 03.4		12 1		24 5		
V Cephei	23 51.7	+82 38	6.0—7.0	0 23.6	5 15;	10 15;	20 14;	30 13		

COMET AND ASTEROID NOTES.

Wolf's Asteroid of February 4.—The following elliptic elements of the object discovered by Wolf on February 4 are given in the Harvard College Observatory Bulletin 655. They were computed by Messrs. Jeffers and Mundt of the Students' Observatory of the University of California, at Berkeley, Cal., from observations made on February 5, 12, and 19. They agree closely with the elements by Stracke given in the March issue of POPULAR ASTRONOMY, so that there is no doubt that the object is an asteroid with a very eccentric orbit.

$T = 1918$ January 3.96 G. M. T.
$\omega = 348° 13'$
$\Omega = 110\ 41$
$i = 9\ 07$
$q = 1.189$
$e = 0.5526$
$P = 4.33$ years

The accompanying diagram shows the relation of the orbit of the asteroid to the orbits of Earth, Mars, and Jupiter. It will at once appear, to the reader who is at all familiar with the elliptic motion, why the apparent motion of this asteroid has been so rapid as compared with others. The eccentricity of the orbit is abnormally large, in fact only one other asteroid has been discovered for which the eccentricity of orbit approaches this one. The other is (719) Albert, for which the eccentricity is 0.540. The velocity of Wolf's asteroid when at perihelion on January 4 was 21.4 miles per second, almost enough to enable it to keep up with the earth

even at its greater distance of 1.189 astronomical units. It was almost at its nearest approach to the earth when it was at perihelion January 4, but was not discovered until a month later, when its distance was beginning to increase rapidly. It seems a pity that this planet could not have been discovered a month or two earlier. If the period of 4.33 years is correct it will again be relatively close to the earth about

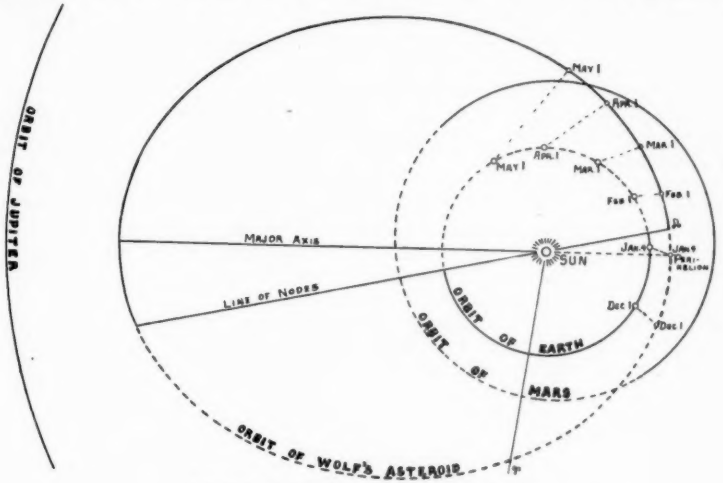


DIAGRAM OF THE ORBIT OF WOLF'S ASTEROID.

the beginning of the year 1931, after having made three revolutions in its orbit. In the same year, and perhaps in the same month, the asteroid Eros will be in the part of its orbit nearest the earth's orbit. The two planetoids might then be used at the same time for determining the distance of the sun.

The following new positions of Wolf's asteroid have come to hand:

G. M. T.	R. A.	Dec.	Observer	Place
	h m s	° ′ ″		
Feb. 16.83254	7 34 11.77	+36 36 38.5	Van Biesbroeck	Williams Bay
17.58626	36 37.30	+36 40 39.9	"	"
19.7309	43 20.6	+36 49 05.8	Barnard	"
19.81549	43 35.63	+36 49 16.3	Van Biesbroeck	"
20.71338	46 23.43	+36 51 30.6	"	"
21.8265	49 48.0	+36 52 57.0	Barnard	"
23.80143	7 55 46.56	+36 53 38.7	Van Biesbroeck	"
28.7597	8 10 13.22	+36 42 58.7	Barnard	"
Mar. 2.5558	15 17.45	+36 35 17.0	"	"
7.7261	8 29 14.12	+36 03 23.7	"	"

Mr. F. E. Seagrave has computed the following ephemeris for April from the elements by Stracke which were given in the March issue of POPULAR ASTRONOMY:

Greenwich Midnight	α	δ	log r	log Δ
	h m s	° ′ ″		
1918 April 1	9 27 02	+31 26 06	0.18388	9.87305
5	35 16	+30 30 16	0.19112	9.89885
9	43 17	+29 33 10	0.19834	9.92408
13	51 05	+28 35 08	0.20550	9.94865
17	9 58 44	+27 35 29	0.21264	9.97275
21	10 06 14	+26 38 19	0.21968	9.99614
25	10 13 35	+25 36 16	0.22668	0.01901

NOTES FOR OBSERVERS.

Monthly Report of the American Association of Variable Star Observers, February-March, 1918.

We extend a welcome this month to five new Charter Members, students of Emory and Henry College, Emory, Va., Messrs. Joseph Brown, C. W. Bruce, Percy V. Dennis, H. J. Horne, and J. W. Painter.

The Creed Fulton Astronomical Observatory and Physical Laboratory at Emory College is equipped with a 6″ equatorial, and these gentlemen have a splendid opportunity to coöperate with us, especially in observing minima. Our total membership is now ninety-seven.

It is with deep regret that we record the death of a loyal member of the Association, the late Paul S. Yendell of Dorchester, Mass., who died February 6, at the age of seventy-three. Mr. Yendell was an observer of variable stars for many years and an authority on the subject; he confirmed the variability of a great number and had attained an international reputation. He contributed many valuable articles on the subject to the "Astronomical Journal" and POPULAR ASTRONOMY and had made over thirty thousand observations. During the past years Mr. Yendell spent much of his leisure time in discussing this great mass of data preparing it for publication. He was a contemporary of Chandler, Gould, and Sawyer, and was well versed in the methods that made these men famous in the annals of Variable Stars. He will ever take his place with them as revered followers of the great Argelander. Mr. Yendell was an enthusiastic member of the Association and contributed many observations to our reports. He will be sadly missed from our ranks. Ever genial and most courteous, endowed with a keen sense of humor, and a knowledge of the Classics, gifted in the fine art of letter writing, his correspondence was replete with interest and charm. The Secretary may be pardoned if he acknowledges herewith in the passing of our late member his heartfelt sense of personal loss. The sympathy of the Association is extended to his bereaved family.

The Secretary received an interesting letter from one of our members "Somewhere in France", Lieutenant Francis H. Hay of the 116th Engineers. Lieutenant Hay writes of traveling fifteen hundred miles in France, observing much that was of interest in that war-smitten country. Monsieur Houdard, another of our members at the Front, contributed a list of fifty-one observations of naked eye variables this month.

Mr. Bouton's list of 143 observations of 76 variables is especially commendable, and his observations of the rapid rise of the variable 235350 R Cassiopeiae are of interest. In this case, the variable increased in brightness 2.8 magnitudes in twenty-two days, an increase of 13.2 times.

The maximum of 213843 SS Cygni was well observed, and Mr. Whitehorn observed a maximum of 074922 U Geminorum February 17.

Mr. Vogelenzang's lists for November and December were delayed in transit and only reached the Secretary this month. They are included in this report to complete the record. Mr. Bancroft's list of 155 observations of 144 variables contributed this month deserves special mention. It is the type of list commended to all our observers, a few observations each month of a large number of variables.

The Spring Meeting of the Association will be held at the home of the President, Mr. D. B. Pickering, 81 S. Burnett St., E. Orange, N. J., at 8 P. M. Saturday May 4. It is hoped that a large number will attend. Those who have enjoyed Mr. Pickering's hospitality in the past will not need to be urged. Those who expect

VARIABLE STAR OBSERVATIONS Feb.-Mar., 1918.

January 0 = 2421594 February 0 = 2421625 March 0 = 2421653

001046
X Androm.

J.D. 242	Est.	Obs.
1625.5	9.6	B
26.5	9.1	V
26.6	9.7	Hu
31.5	9.2	V
34.7	9.0	Me
47.5	9.1	B
54.5	9.2	Ba

001726
T Androm.

242		
1637.6	9.2	Pi
55.5	9.6	Ba

001755
T Cassiop.

242		
1622.5	10.7	B
31.5	11.1	B
45.5	11.1	B
55.5	10.0	Ba

001838
R Androm.

242		
1637.6	<10.6	Pi
55.5	<12.0	Ba

003179
Y Cephei

242		
1626.6	<12.6	Hu
54.5	<13.3	Ba

004047
U Cassiop.

242		
1622.5	8.0	B
26.6	8.4	Y
31.5	8.3	B
37.6	8.6	Pi
42.6	8.4	Wh
47.5	8.8	B
54.6	9.1	Ba

004132
RW Androm.

242		
1625.5	<12.0	B
55.5	<12.5	Ba

004435
V Androm.

242		
1622.5	9.2	B
26.5	9.2	V
26.6	9.2	Hu
31.5	9.5	B
31.5	9.0	V
55.5	10.3	Ba

004533
RR Androm

242		
1627.7	<12.6	Me
55.5	<12.0	Ba

004746
RV Cassiop.

242		
1627.7	<13.2	Me
54.6	<13.0	Ba

004958
W Cassiop.

J.D. 242	Est.	Obs.
1623.6	11.7	B
31.5	11.5	B
37.6	<11.0	Pi
42.6	11.5	Wh
55.5	12.0	Ba

010940
U Androm.

242		
1637.6	<10.8	Pi
54.6	<13.1	Ba

011272
S Cassiop.

242		
1642.6	<12.3	Wh
54.6	<13.0	Ba

011208
S Piscium

242		
1627.5	12.2	Y
29.5	<11.3	V
40.8	9.9	By

011712
U Piscium

242		
1540.5	12.5	Ba
1655.5	<12.6	Ba

012350
RZ Persei

242		
1626.6	12.2	Y
55.6	10.2	Ba

013238
RU Androm.

242		
1654.6	12.5	Ba

013338
Y Androm.

242		
1627.7	13.3	Me
42.6	<12.6	Hu
54.6	10.9	Ba

014958
X Cassiop.

242		
1626.6	<12.5	Y
27.6	<12.5	B
37.6	<11.6	Pi
55.6	<12.6	Ba

015354
U Persei

242		
1622.5	10.5	B
31.5	10.6	B
32.7	11.0	Mu
33.6	10.6	Hu
37.6	10.8	Pi
42.6	10.6	Wh
45.5	10.6	B
55.6	10.7	Ba

015912
S Arietis

242		
1655.6	<12.0	Ba

021024
R Arietis

J.D. 242	Est.	Obs.
1637.6	9.6	Pi
38.6	9.7	Al
55.6	8.5	Ba

021143
W Androm.

242		
1633.6	<12.0	Wh
55.6	12.2	Ba

021281
Z Cephei

242		
1540.6	12.6	Ba
1655.6	<13.3	Ba

021356
SU Persei

242		
1540.2	8.1	Vo
78.2	8.0	Vo
81.2	8.1	Vo
85.2	8.0	Vo

021403
o Ceti

242		
1537.6	3.8	Ba
39.4	4.0	Vo
40.4	4.0	Vo
40.6	3.8	Ba
44.4	4.1	Vo
47.4	4.0	Vo
56.4	4.1	Vo
65.3	4.1	Ba
65.3	4.4	Vo
67.2	4.5	Vo
74.3	4.8	Vo
78.2	4.8	Vo
80.2	4.9	Vo
81.2	5.0	Vo
85.2	4.9	Vo
99	5.2	Pe
1605	5.5	Pe
07	5.5	Pe
08	5.6	Pe
32.6	5.9	Mu
39.7	6.2	Mu
42.6	5.9	Hu
55.6	6.8	Ba

021558
S Persei

242		
1624.6	9.2	B
28.7	9.3	Me
31.5	9.2	B
55.6	9.0	Ba

022000
R Ceti

242		
1655.5	<12.0	Ba

022150
RR Persei

J.D. 242	Est.	Obs.
1626.6	11.5	Y
37.6	<11.9	Pi
54.6	13.5	Ba

022813
U Ceti

242		
1626.5	12.0	Y
29.5	10.5	B

023080
RR Cephei

242		
1540.6	<13.7	Ba
1655.6	10.6	Ba

023133
R Trianguli

242		
1626.6	9.6	Hu
27.6	11.3	B
33.6	11.3	Wh
55.6	9.7	Ba

024356
W Persei

242		
1565.6	8.7	Ba
85.5	8.9	Ba
1625.6	8.8	Wh
32.7	9.4	Mu
33.6	8.9	Hu
55.6	8.4	Ba

030514
U Arietis

242		
1537.6	<14.0	Ba
85.5	<13.3	Ba
1626.6	13.3	Y
28.7	13.5	Me
54.5	10.8	Ba

031401
X Ceti

242		
1655.6	9.5	Ba

032043
Y Persei

242		
1631.5	10.2	B
33.6	9.0	Hu
55.6	9.6	Ba

032335
R Persei

242		
1633.6	8.3	Hu
33.6	8.1	Wh
55.6	8.7	Ba

033362
U Camelop.

242		
1655.6	7.3	Ba

035915
V Eridani

242		
1655.6	8.0	Ba

041619
T Tauri

J.D. 242	Est.	Obs.
1649.6	<9.8	M
55.6	9.5	Ba

042209
R Tauri

242		
1585.6	<13.0	Ba
1625.6	<11.6	Wh
33.6	<12.0	Hu
34.7	11.5	Me
39.6	10.9	B
49.6	9.8	M
54.6	9.7	Ba

042215
W Tauri

242		
1537.6	10.6	Ba
40.6	10.7	Ba
44.6	11.2	Ba
50.6	11.7	Ba
58.6	11.7	Ba
85.5	<12.6	Ba
1608	11.7	Pe
23.6	12.1	B
31.6	11.8	B
32.7	<10.4	Mu
38.6	10.8	Y
39.6	12.6±	Pi
49.6	<10.4	M
54.5	10.7	Ba

042309
S Tauri

242		
1585.6	<13.0	Ba
1625.6	<11.6	Wh
34.7	<13.0	Me
39.6	<13.0	B
54.6	<13.5	Ba

043065
T Camelop.

242		
1585.6	<13.3	Ba
1634.7	<10.3	Me
54.6	9.9	Ba

043208
RX Tauri

242		
1623.6	<12.0	B
31.6	12.2	B
39.6	<11.5	Pi
55.6	<13.0	Ba

043274
X Camelop.

242		
1537.5	8.7	Ba
50.5	9.8	Ba
85.5	12.6	Ba
1627.6	9.1	B
39.7	8.6	B
45.6	8.5	Wh
54.5	8.0	Ba

VARIABLE STAR OBSERVATIONS, Feb.-Mar., 1918—Continued.

044617
V Tauri

J.D. 242	Est.	Obs.
1623.6	<12.0	B
31.6	<12.8	B
39.6	<11.5	Pi
55.6	12.5	Ba

045307
R Orionis

J.D. 242	Est.	Obs.
1626.5	12.4	B
34.5	12.2	B
38.6	11.7	Y
55.6	11.6	Ba

045514
R Leporis

J.D. 242	Est.	Obs.
1626.6	7.3	B
34.6	7.9	B
39.6	8.5	Pi
55.6	6.8	Ba

050022
T Leporis

J.D. 242	Est.	Obs.
1639.6	9.5	Pi
55.6	9.6	Ba

050003
V Orionis

J.D. 242	Est.	Obs.
1585.6	<12.8	Ba
1629.5	12.4	B
32.6	12.4	Wh
37.7	11.2	Me
38.6	11.3	Al
38.6	11.0	Y
40.6	12.1	Wh
51.6	11.2	Wh
54.6	11.0	Ba

050953
R Aurigae

J.D. 242	Est.	Obs.
1629.6	10.5	B
55.6	11.1	Ba

052034
S Aurigae

J.D. 242	Est.	Obs.
1626.5	9.0	B
34.6	9.5	B
36.7	9.6	Pi
55.6	8.8	Ba

052036
W Aurigae

J.D. 242	Est.	Obs.
1633.6	12.6	B
55.6	<12.5	Ba

052404
S Orionis

J.D. 242	Est.	Obs.
1585.6	9.4	Ba
1626.5	7.7	B
34.5	7.8	B
47.5	7.7	B
54.6	7.4	Ba

*053005*a
T Orionis

J.D. 242	Est.	Obs.
1608	10.8	Pe
24.5	10.1	B
31.5	9.9	B
32.7	10.1	Mu
33.6	10.6	Hu
33.6	10.5	Wh
34.8	9.9	By
35.7	10.1	Me
40.6	10.2	Wh
44.5	9.7	B
51.6	10.2	Wh
55.6	9.9	Ba

053068
S Camelop.

J.D. 242	Est.	Obs.
1655.6	9.4	Ba

053531
U Aurigae

J.D. 242	Est.	Obs.
1626.5	11.5	B
34.6	11.0	B
36.7	11.5	Pi
43.6	11.4	Y
55.7	11.3	Ba

053920
Y Tauri

J.D. 242	Est.	Obs.
1540.4	7.2	Vo
66.4	7.0	Vo
67.4	7.1	Vo
80.3	7.3	Vo

054319
SU Tauri

J.D. 242	Est.	Obs.
1537.6	9.4	Ba
39.6	9.6	Ba
40.6	9.6	Ba
44.6	9.5	Ba
50.6	9.6	Ba
58.6	9.7	Ba
85.5	9.5	Ba
1608	10.0	Pe
22.5	9.6	B
26.5	9.6	B
29.5	9.5	B
29.5	9.4	V
30.5	9.6	B
33.5	9.5	B
33.6	9.7	Wh
34.5	9.6	B
34.7	9.4	Me
37.6	9.4	Pi
37.7	9.4	Me
38.6	9.5	Y
39.5	9.5	B
47.5	9.5	B
51.6	9.7	Wh
54.5	9.3	Ba
55.6	9.4	Ba
56.5	9.5	Ba

054615
RU Tauri

J.D. 242	Est.	Obs.
1638.6	12.0	Y

054615a
Z Tauri

J.D. 242	Est.	Obs.
1638.6	10.8	Y

054920
U Orionis

J.D. 242	Est.	Obs.
1608	11.1	Pe
24.6	11.6	B
26.6	11.6	Hu
33.5	11.9	B
37.6	11.6	Pi
55.7	11.0	Ba

054974
V Camelop.

J.D. 242	Est.	Obs.
1535.5	<13.2	Ba
37.5	<13.3	Ba
40.5	<13.5	Ba
44.5	<13.0	Ba
50.5	<13.5	Ba
58.6	<12.8	Ba
85.5	<12.8	Ba
1632.6	<12.2	Wh
39.6	<13.0	B
40.6	<12.2	Wh
51.6	<12.2	Wh
54.5	<13.2	Ba
55.6	<13.0	Ba
56.5	<13.3	Ba

055353
Z Aurigae

J.D. 242	Est.	Obs.
1636.7	10.9	Pi
55.7	11.5	Ba

060450
X Aurigae

J.D. 242	Est.	Obs.
1585.6	12.5	Ba
1629.5	10.3	B
33.6	10.9	Hu
36.6	9.6	Pi
40.7	9.2	Wh
54.6	8.7	Ba

060547
SS Aurigae

J.D. 242	Est.	Obs.
1539.7	13.0	Ba
40.6	13.5	Ba
44.6	<13.0	Ba
50.6	<13.5	Ba
58.6	<12.5	Ba
85.5	<12.8	Ba
1626.6	<13.3	Y
29.5	<11.2	V
34.8	12.6	By
35.7	<12.4	Me
36.6	<11.4	Pi
40.6	<12.4	Wh
40.8	12.3	By
54.6	<13.3	Ba
55.6	<13.0	Ba
56.5	<13.3	Ba

061647
V Aurigae

J.D. 242	Est.	Obs.
1626.5	10.8	B
39.5	10.9	B
55.7	11.6	Ba

061702
V Monoc.

J.D. 242	Est.	Obs.
1655.7	11.7	Ba

063159
U Lyncis

J.D. 242	Est.	Obs.
1539.7	10.5	Ba
85.6	9.5	Ba
1633.6	11.0	B
43.6	11.4	Y
54.6	11.7	Ba

063308
R Monoc.

J.D. 242	Est.	Obs.
1626.5	11.3	B
55.7	11.7	Ba

063558
S Lyncis

J.D. 242	Est.	Obs.
1539.7	12.6	Ba
85.6	<13.0	Ba
1622.5	<12.7	B
33.5	12.9	B
54.6	<13.5	Ba

064030
X Gemin.

J.D. 242	Est.	Obs.
1585.6	8.6	Ba
1626.6	9.1	V
31.5	9.2	V
54.6	10.9	Ba

065111
Y Monoc.

J.D. 242	Est.	Obs.
1585.6	11.6	Ba
1638.6	<12.5	Y
54.6	13.3	Ba

065208
X Monoc.

J.D. 242	Est.	Obs.
1638.6	8.2	Hu
55.7	9.0	Ba

065355
R Lyncis

J.D. 242	Est.	Obs.
1539.7	13.1	Ba
1643.6	8.8	Y
55.7	8.7	Ba

*070122*a
R Gemin.

J.D. 242	Est.	Obs.
1540.4	7.3	Vo
67.4	7.7	Vo
1608	10.6	Pe
22.5	9.8	B
32.5	10.0	B
33.6	9.7	Hu
51.6	10.8	Wh
55.7	11.0	Ba

070122b
Z Gemin.

J.D. 242	Est.	Obs.
1608	12.2	Pe
22.5	<11.7	B
32.6	12.6	B
51.6	<12.1	Wh
55.7	12.4	Ba

070122c
TW Gemin.

J.D. 242	Est.	Obs.
1608	8.2	Pe
22.5	8.2	B
32.5	8.3	B
51.6	8.5	Wh
55.7	8.4	Ba

070310
R Can. Min.

J.D. 242	Est.	Obs.
1625.5	9.4	B
38.6	8.7	Hu
40.5	9.0	B
56.6	8.4	Ba

071713
V Gemin.

J.D. 242	Est.	Obs.
1585.6	8.3	Ba
1625.6	10.5	B
40.5	11.9	B
51.6	11.5	Wh
54.6	11.9	Ba

072708
S Can. Min.

J.D. 242	Est.	Obs.
1608	10.2	Pe
25.6	10.4	B
27.8	11.2	By
32.7	<10.0	Mu
40.5	11.5	B
40.6	11.1	Wh
56.6	12.2	Ba

072811
T Can. Min.

J.D. 242	Est.	Obs.
1639.5	13.2	B
56.6	<14.2	Ba

073508
U Can. Min.

J.D. 242	Est.	Obs.
1625.6	8.9	B
26.6	9.5	Y
38.6	9.3	Hu
56.6	9.1	Ba

073723
S Gemin.

J.D. 242	Est.	Obs.
1540.7	13.3	Ba
85.6	10.0	Ba
1622.5	9.7	B
26.6	9.8	V
31.5	9.9	V
32.6	10.0	B
36.8	9.9	M
42.7	10.5	Wh
54.7	11.4	Ba

074323
T Gemin.

J.D. 242	Est.	Obs.
1540.7	<13.1	Ba
85.6	10.9	Ba
1626.6	9.5	V
31.6	9.2	V
33.6	10.0	Hu
36.8	9.1	M
39.7	9.0	B
42.6	9.0	Wh
54.7	8.4	Ba

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074922
U Gemin.
J.D. Est. Obs.
242
1540.7<13.3 Ba
50.6<12.5 Ba
85.6<13.7 Ba
1626.6<11.7 V
26.6<13.3 Y
29.5<13.0 B
33.5<12.6 B
33.5<12.6 B
33.6<12.0 Hu
34.6<13.3 B
34.7<13.3 Me
36.7<12.3 Pi
36.8<11.7 M
38.6<13.3 Y
38.7<14.1 Al
39.5<13.3 B
40.7<12.3 Wh
42.7 9.8 Wh
54.7<13.5 Ba
55.6<13.6 Ba
56.6 13.5 Ba

075612
U Puppis
1635.7 12.4 Me
39.6<13.0 B
56.6 12.2 Ba

081112
R Cancri
1624.6 9.3 B
32.6 9.5 B
42.6 8.6 Hu
51.7 9.2 Wh
56.6 8.8 Ba

081633
T Lyncis
1642.6 8.2 Hu

081617
V Cancri
1629.6 12.4 B
56.6 10.2 Ba

082405
RT Hydrae
1625.6 8.5 B
40.5 8.1 B
56.6 7.6 Ba

083019
U Cancri
1654.7<13.3 Ba

083350
X Urs Maj.
1626.6 12.5 B
39.6<12.6 B
54.7<12.5 Ba

084803
S Hydrae
J.D. Est. Obs.
242
1625.6 8.1 B
38.6 8.3 Hu
39.6 8.4 Pi
40.5 8.3 B
56.6 8.6 Ba

085008
T Hydrae
1656.6 9.3 Ba

085120
T Cancri
1634.6 8.8 B
56.6 7.8 Ba

090151
V Urs. Maj.
1608 10.4 Pe
26.6 10.5 B
32.7 10.3 Hu
42.6 9.2 Hu
45.7 10.4 B
56.6 10.6 Ba

090425
W Cancri
1639.5<13.3 B
54.7<13.8 Ba

093014
X Hydrae
1656.6 12.0 Ba

093178
Y Dracon s
1643.6 9.7 Y

093934
R Leo. Min.
1625.6 6.6 B
36.8 7.6 M
38.6 6.7 Hu
40.5 7.1 B
56.6 7.0 Ba

094211
R Leonis
1608 10.1 Pe
26.6 9.1 B
27.8 10.3 By
34.6 9.1 B
36.8 9.9 M
40.6 9.1 Wh
54.6 9.3 Pt
56.6 8.6 Ba

095421
V Leonis
1634.8 9.5 By
38.6 9.0 Hu
39.6 9.3 B
45.6 9.1 B
56.6 8.9 Ba

103212
U Hydrae
J.D. Est. Obs.
242
1656.6 4.7 Ba

103769
R Urs. Maj.
1622.6<12.0 B
30.6 12.7 B
49.6<11.0 M
56.6 12.4 Ba

104620
V Hydrae
1656.6 6.7 Ba

104814
W Leonis
1626.6 12.4 Y
32.6<12.4 B
38.6 12.5 Y
42.6 12.2 Hu
56.6 13.0 Ba

115919
R Comae
1639.6<12.5 B
54.7<12.5 Ba

120012
SU Virginis
1654.7 11.5 Ba

120905
T Virginis
1656.7 11.0 Ba

121418
R Corvi
1628.8 8.5 M
56.7 9.5 Ba

122001
SS Virginis
1628.8 7.7 M
54.7 7.4 Ba

122532
T Can. Ven.
1628.8 9.8 M
56.5 9.6 Ba

122803
Y Virginis
1656.7<13.0 Ba

123160
T Urs. Maj.
1540.5 7.9 Ba
1608 11.7 Pe
27.6<12.4 B
28.8<10.8 M
34.7<12.3 Me
36.8<11.3 M
38.6 12.5 Y
43.6<11.0 Wh
56.5 13.0 Ba

123307
R Virginis
J.D. Est. Obs.
242
1628.8 6.9 M
56.7 8.3 Ba

123459
RS Urs. Maj.
1540.5 12.8 Ba
1627.6 8.9 B
28.8 9.2 M
34.7 9.1 Me
43.6 9.4 Wh
54.7 9.2 Ba
55.6 9.2 Pt

123961
S Urs. Maj.
1540.5 7.6 Ba
1608. 9.1 Pe
27.6 10.0 B
28.8 10.1 M
34.7 10.3 Me
38.6 10.1 Y
43.6 10.4 Wh
54.7 10.7 Ba

124204
RU Virginis
1654.7 11.0 Ba

124606
U Virginis
1654.7 10.7 Ba

132202
V Virginis
1656.7 12.6 Ba

132706
S Virginis
1656.7 8.3 Ba

133273
T Urs. Min.
1540.5 13.2 Ba
1656.5 10.9 Ba

134440
R Can. Ven.
1537.5 7.7 Ba
1628.8 10.3 M
43.6 10.6 Y
54.7 10.6 Ba

135908
RR Virginis
1656.7<13.0 Ba

140113
Z Bootis
1656.7 13.0 Ba

140512
Z Virginis
1656.7 12.5 Ba

141567
U Urs. Min.
J.D. Est. Obs.
242
1535.5 8.7 Ba
40.5 8.8 Ba
1639.6 11.0 B
46.6 11.6 Wh
54.7 11.5 Ba

141954
S Bootis
1535.5 11.6 Ba
40.5 11.3 Ba
1628.8 10.4 M
46.6 9.1 Wh
54.7 9.6 Ba

142205
RS Virginis
1656.7 13.0 Ba

142539
V Bootis
1537.5 7.9 Ba
1628.8 7.7 M
54.7 8.6 Ba

142584
R Camelop.
1540.5 8.3 Ba
1622.6 10.2 B
33.6 10.7 B
45.6<11.0 B
54.7 12.5 Ba

143227
R Bootis
1537.5 8.9 Ba
1654.7 10.1 Ba

144918
U Bootis
1636.8 11.6 M
56.7 11.1 Ba

151520
S Librae
1645.9 8.6 M

151731
S Cor. Bor.
1537.5 11.5 Ba
1629.9 7.7 M
54.7 7.6 Ba

151714
S Serpentis
1537.5 11.2 Ba
1656.7 11.5 Ba

151822
RS Librae
1645.9 8.0 M

152714
RU Librae
1645.9 8.8 M

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153020
X Librae
J.D. Est. Obs.
242
1645.9 < 11.0 M

153215
W Librae
1645.9 < 10.9 M

153378
S Urs. Min.
1535.5 10.2 Ba
1639.6 8.1 B
54.7 8.3 Ba

154428
R Cor. Bor.
1540.5 10.3 Ba
44.5 10.2 Ba
50.5 10.4 Ba
58.5 10.9 Ba
1628.8 8.7 M
29.9 8.7 M
36.7 9.2 Pi
36.8 8.5 M
45.8 8.8 M
54.7 9.0 Ba
55.7 8.9 Ba
56.7 8.8 Ba

154536
X Cor. Bor.
1537.5 9.9 Ba
1645.8 < 12.2 M
56.7 13.0 Ba

154639
V Cor. Bor.
1537.5 6.7 Ba
1656.7 7.7 Ba

154639
Y Cor. Bor.
1629.9 8.7 M
45.8 8.8 M

154615
R Serpentis
1537.5 < 12.5 Ba
1629.9 8.9 M

154715
R Librae
1645.8 < 11.0 M

155229
Z Cor. Bor.
1537.5 < 13.3 Ba

155847
X Herculis
1540.5 6.2 Ba
1640.2 7.2 Vo
80.2 7.3 Vo

160118
R Herculis
J.D. Est.Obs.
242
1537.5 10.1 Ba

160210
U Serpentis
1537.5 < 12.0 Ba
1629.9 9.0 M
56.7 9.1 Ba

160625
RR Herculis
1535.5 10.2 Ba
1629.9 11.1 M

161122a
R Scorpii
1645.9 < 11.5 M

161122b
S Scorpii
1745.9 < 11.5 M

161122c
T Scorpii
1645.9 11.0 M

161138
W Cor. Bor.
1535.5 8.4 Ba
1629.9 < 11.2 M

162119
U Herculis
1535.5 9.8 Ba
1629.9 < 10.9 M

162542
g Herculis
1540.2 4.8 Vo
80.2 6.9 Vo

162807
SS Herculis
1537.5 12.4 Ba

163137
W Herculis
1535.5 8.6 Ba
1629.9 < 11.2 M

163172
R Urs. Min.
1535.5 9.7 Ba
1629.9 9.4 M
39.7 9.5 B
54.7 9.2 Ba

163266
R Draconis
1535.5 11.3 Ba
1629.9 11.0 M
56.5 9.5 Ba

164055
S Draconis
1535.5 8.7 Ba
1629.9 9.0 M

164715
S Herculis
J.D. Est.Obs.
242
1535.5 8.2 Ba

165631
RV Herculis
1535.5 10.5 Ba
1629.9 < 11.8 M

170215
R Ophiuchi
1645.9 < 10.7 M

170627
RT Herculis
1535.5 < 12.4 Ba
1645.9 11.2 M

171401
Z Ophiuchi
1537.5 12.5 Bu

171723
RS Herculis
1537.5 12.2 Ba
1645.9 8.0 M

172808
RU Ophiuchi
1537.5 13.0 Ba
1645.9 10.8 M

175111
RT Ophiuchi
1537.5 < 12.7 Ba

175519
RY Herculis
1537.5 8.9 Ba

180531
T Herculis
1537.5 7.5 Ba
1629.9 < 11.0 M

180565
W Draconis
1537.5 < 12.5 Ba
58.5 < 12.8 Ba
85.5 11.7 Ba
1656.5 10.3 Ba

180666
X Draconis
1558.5 12.4 Ba
85.5 < 12.0 Ba
1656.5 10.4 Ba

181136
W Lyrae
1537.5 9.6 Ba
1645.9 8.6 M

181103
RY Ophiuchi
1537.5 11.8 Ba

182224
SV Herculis
1537.5 10.9 Ba

182306
T Serpentis
1537.5 < 13.0 Ba

183225
RZ Herculis
1537.5 13.4 Ba

183308
X Ophiuchi
1537.6 8.4 Ba
40.2 8.2 Vo

184134
RY Lyrae
1537.6 9.4 Ba

184205
R Scuti
1535.5 5.7 Ba
37.5 5.6 Ba
40.2 5.6 Vo
40.5 5.5 Ba
44.5 5.7 Ba
50.5 5.6 Ba
58.2 5.4 Vo
58.5 5.3 Ba

184243
RW Lyrae
1537.6 < 13.7 Ba

185032
RX Lyrae
1537.6 < 13.3 Ba

185243
R Lyrae
1540.2 4.3 Vo
44.3 4.3 Vo
58.2 4.3 Vo
78.2 4.3 Vo
80.2 4.3 Vo
81.2 4.4 Vo

185634
Z Lyrae
1537.6 12.0 Ba

190108
R Aquilae
1537.6 11.0 Ba

190529
V Lyrae
1537.6 < 13.3 Ba

190907
TY Aquilae
1540.5 10.5 Ba

190926
X Lyrae
1537.6 8.7 Ba

190967
U Draconis
1537.6 10.1 Ba

191007
W Aquilae
J.D. Est.Obs
242
1540.5 9.2 Ba

191019
R Sagittarii
1544.5 11.4 Ba

191350
TZ Cygni
1537.6 10.8 Ba
85.5 10.2 Ba

191637
U Lyrae
1537.6 9.2 Ba

192745
AF Cygni
1540.2 7.5 Vo
61.2 7.5 Vo
67.2 7.5 Vo
78.2 7.7 Vo
81.2 7.7 Vo

192928
TY Cygni
1537.6 < 13.3 Ba
1645.9 9.5 M

193311
RT Aquilae
1537.6 < 13.8 Ba

193449
R Cygni
1537.6 8.7 Ba
85.5 9.5 Ba

193509
RV Aquilae
1537.6 < 13.3 Ba

193732
TT Cygni
1537.6 7.5 Ba

194048
RT Cygni
1537.6 9.0 Ba

194348
TU Cygni
1537.6 11.6 Ba

194604
X Aquilae
1540.5 < 13.0 Ba

194632
χ Cygni
1537.6 13.0 Ba

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195849
Z Cygni
J.D. Est.Obs.
242
1537.6 12.6 Ba
85.5 12.1 Ba

200212
SY Aquilae
1540.5<12.5 Ba

200357
S Cygni
1537.6 10.2 Ba

200647
SV Cygni
1537.6 8.2 Ba

200715a
S Aquilae
1537.6 9.5 Ba

200715b
RW Aquilae
1537.6 9.0 Ba

200812
RU Aquilae
1540.5 12.0 Ba

200906
Z Aquilae
1540.5<13.6 Ba

200916
R Sagittae
1537.6 8.7 Ba

200938
RS Cygni
1537.6 8.0 Ba

201008
R Delphini
1544.5 8.5 Ba
85.5 9.7 Ba

201121
RT Capricorni
1544.5 6.8 Ba

201130
SX Cygni
1544.5 10.5 Ba

201647
U Cygni
1537.6 8.2 Ba

202539
RW Cygni
1544.5 7.5 Ba

202817
Z Delphini
J.D. Est.Obs.
242
1544.5<13.6 Ba
85.5 11.0 Ba

202946
SZ Cygni
1535.5 8.8 Ba
37.5 9.1 Ba
39.6 9.4 Ba
40.5 9.5 Ba
44.5 9.7 Ba
50.5 8.9 Ba
58.5 9.6 Ba
85.5 9.2 Ba

202954
ST Cygni
1544.5 12.6 Ba

203226
V Vulpeculae
1544.5 9.0 Ba

203611
Y Delphini
1544.5<12.5 Ba

203816
S Delphini
1544.5 9.3 Ba

203847
V Cygni
1544.5 10.3 Ba

204016
T Delphini
1544.5<12.5 Ba

204017
U Delphini
1539.2 6.7 Vo
58.2 6.5 Vo
78.2 6.7 Vo
86.2 6.8 Vo
88.2 6.9 Vo

204318
V Delphini
1544.6<12.7 Ba

204405
T Aquarii
1544.5 8.4 Ba

204846
RZ Cygni
J.D. Est.Obs.
242
1550.6 12.2 Ba

205017
X Delphini
1550.6 9.1 Ba

205030
UX Cygni
1550.6 11.7 Ba

205923
R Vulpeculae
1550.6 9.1 Ba

210116
RS Capricorni
1544.5 8.1 Ba

210129
TW Cygni
1550.6<13.0 Ba

210868
T Cephei
1540.2 8.0 Vo
50.6 7.0 Ba
61.2 7.1 Vo
67.2 6.9 Vo
78.2 6.5 Vo
81.2 6.5 Vo
85.2 6.2 Vo
1656.5 6.4 Ba

211614
X Pegasi
1550.6 9.2 Ba

211615
T Capricorni
1544.5 13.2 Ba

213244
W Cygni
1539.3 5.8 Vo
61.2 5.5 Vo
67.2 5.5 Vo
78.2 6.0 Vo
81.2 5.9 Vo
85.2 5.8 Vo

213678
S Cephei
1550.6 10.4 Ba
1627.5<12.0 B
56.5 13.6 Ba

213753
RU Cygni
J.D. Est.Obs.
242
1558.5 7.3 Ba

213843
SS Cygni
1539.7 11.2 Ba
40.5 11.4 Ba
44.4 11.5 Ba
50.6 11.7 Ba
58.5 11.7 Ba
85.5 11.9 Ba
1622.5 11.3 B
23.5 10.3 B
25.5 8.7 B
26.4 8.7 B
25.5 8.8 V
26.5 8.9 Y
27.5 8.6 B
27.5 8.7 Y
29.5 8.7 B
29.5 8.3 V
30.5 8.6 B
31.5 8.7 B
31.5 8.6 V
33.5 8.8 B
34.5 8.9 B

213937
RV Cygni
1550.6 6.7 Ba

214024
RR Pegasi
1550.6 9.4 Ba

215605
V Pegasi
1550.6 10.0 Ba

215834
RT Pegasi
1550.7<13.0 Ba

220412
T Pegasi
1550.6<13.0 Ba

220613
Y Pegasi
1558.5 11.4 Ba

220714
RS Pegasi
1558.5<12.5 Ba

222439
S Lacertae
1558.5 10.7 Ba
1627.5 12.7 B

225120
S Aquarii
J.D. Est.Obs.
242
1544.5<13.2 Ba

225914
RW Pegasi
1558.5<12.4 Ba
1626.5<13.2 Y
27.5<12.3 D

230110
R Pegasi
1558.5 9.8 Ba
1608 7.5 Pe
27.5 8.5 Y

230759
V Cassiop.
1558.5 10.6 Ba
1625.5<12.0 B
42.6 10.9 Wh
56.5 10.7 Ba

231425
W Pegasi
1558.5 12.3 Ba

233335
ST Androm.
1627.5 10.4 B
37.6 10.0 Pi

233815
R Aquarii
1544.5 7.0 Ba

233956
Z Cassiop.
1656.5 13.0 Ba

235209
V Ceti
1544.5<13.6 Ba

235350
R Cassiop.
1623.6 10.6 B
31.5 9.7 B
45.5 7.8 Ba
56.5 6.7 Ba

235939
SV Androm.
1626.5 12.1 Y
37.6<11.6 Pi

No. of Observations 884; No. of Stars Observed 255; No. of Observers 16.

to attend are requested to notify the Secretary immediately in order that Mr. Pickering may make the proper arrangements. The courtesy of a prompt reply to this invitation is requested.

The following dates from Mr. Leon Campbell's list of calculated dates of Maxima and Minima are of interest:—

Mar.	9	043274	X Camelop.	Max.	Mar.	23	154615	R Serpentis	Max.
	10	194048	RT Cygni	Min.		23	235350	R Cassiop.	Max.
	20	*204405*	T Aquarii	Min.		24	123961	S Urs. Maj.	Min.
	22	201008	R Delphini	Min.		27	123307	R Virginis	Min.

The following members contributed to this report:—Miss Allen, Messrs. Bancroft, Bouton, Bryan, De Perrot, Houdard, Hunter, McAteer, Meeker, Mundt, Peltier, D. Pickering, Vogelenzang, Vrooman, Whitehorn, Miss Young.

WILLIAM TYLER OLCOTT,
Secretary.

Norwich, Conn.
Mar. 10, 1918.

Charter Members of the American Association of Variable Star Observers.

Rev. M. J. Ahern, Boston College, Brookline, Mass.
Miss L. B. Allen, Wellesley College, Wellesley, Mass.
Charles K. Arter, Cleveland, O.
R. W. Augustine, Chicago, Ill.
E. L. Baldwin, Denver Col.
H. C. Bancroft, Jr., W. Collingswood, N. J.
Lemont Barbour, New York City.
C. E. Barns, Morgan Hill, Cal.
Signor D. Benini, Faenza, Italy.
David A. Blencoe, Superior, Wis.
Miss D. W. Block, Harvard College Observatory, Cambridge, Mass.
A. T. Bolfing, Hayward, Cal.
Rev. T. C. H. Bouton, Hudson, N. H.
F. E. Brasch, Chicago Ill.
Mrs. E. T. Brewster, Andover, Mass.
Charles A. Bruun, Kansas City, Mo.
E. H. Bryan, Honolulu.
A. B. Burbeck, N. Abington, Mass.
Leon Campbell, Harvard College Observatory, Cambridge, Mass.
Mrs. I. F. Conant, Wellesley, Mass.
Charles H. Cramer, Sandusky, O.
* John J. Crane, Sandwich, Mass.
B. H. Dawson, La Plata, Argentina.
W. J. Delmhorst, Jersey City, N. J.
L. T. Donovan, Los Angeles, Cal.
F. L. Ducharme, Arlington, Mass.
J. Duff, Regina, Canada.
C. W. Elmer, New York City.
E. L. Forsyth, Needles, Cal.
Vincent Francis, New Bedford, Mass.
Dr. Caroline E. Furness, Vassar College, Poughkeepsie, N. Y.

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* Those whose names are starred are Life Members.

Paul Gmelin, Cranford, N. J.
E. L. Gould, E. Orange, N. J.
Dr. Edward Gray, Berkeley, Cal.
A. W. Gregory, Morristown, N. Y.
Rev. J. G. Hagen, Vatican Observatory, Rome.
Miss M. Alberta Hawes, Harvard College Observatory, Cambridge, Mass.
F. H. Hay, Los Angeles, Cal.
William Herriott, Canadaigua, N. Y.
G. Houdard, St. Germaine en Lay, France.
* S. C. Hunter, New Rochelle, N. Y.
M. W. Jacobs, Harrisburg, Pa.
M. J. Jordan, Boston, Mass.
Signor G. B. Lacchini, Faenza, Italy.
Dr. C. J. Larsen, Negaunee, Mich.
F. C. Leonard, Chicago, Ill.
C. B. Lindsley, Berea, Ky.
W. J. Luyten, Deventer, Holland.
C. Y. McAteer, Pittsburg, Pa.
E. S. McColl, New York, City.
* W. P. Meeker, Roland Park, Md.
Edmund Mills, Jersey City, N. J.
W. D. Morgan, Minneapolis, Minn.
C. S. Mundt, Alameda, Cal.
W. B. Newberry, Cleveland, O.
G. F. Nolte, New York City.
A. H. Norton, Elmira, N. Y.
* W. T. Olcott, Norwich, Conn.
* C. Pardo, New York City.
Professor J. A. Parkhurst, Yerkes Observatory, Williams Bay, Wis.
H. H. Pease, Philadelphia, Pa.
Ed. de Perrot, Yverdon, Switzerland.
C. A Phillips, Elmira, N. Y.
Professor E. C. Pickering, Director Harvard College Observatory, Cambridge, Mass.
* David B. Pickering, E. Orange, N. J.
S. W. Pickering, E. Orange, N. J.
E. W. Putnam, New York City.
Miss Susan Raymond, Smith College, Northampton Mass.
W. H. Reardon, N. Abington, Mass.
Miss Dorothy Reed, Boston, Mass.
H. G. Rich, Chicago, Ill.
Charles F. Richter, Leland Stanford University, Cal.
Fr. Luis Rodés Chicago, Ill.
* H. R. Schulmaier, Berwick, Me.
F. H. Spinney, Hudson, N. H.
* Rev. Victor Stepka, Clayton, Mo.
* Miss H. M. Swartz, S. Norwalk, Conn.
Mrs. Alice M. Swing, Cocoanut Grove, Fla.
Miss M. H. Vann, Harvard College Observatory, Cambridge, Mass.
E. H. Vogelenzang, Hilversum, Holland.
H. W. Vrooman, Kokomo, Ind.
Richard B. Waterhouse, Bourne, Mass.
Miss Ada Weber, Cincinnati, O.

Charles T. Whitehorn, Bloomfield, N. J.
David Wilson, Harvard University, Cambridge, Mass.
Miss I. E. Woods, Harvard College Observatory, Cambridge, Mass.
Paul S. Yendell, Dorchester, Mass. (Deceased).
Professor Anne S. Young, Mt. Holyoke College, S. Hadley, Mass.

COMMUNICATIONS.

The Meteor of January 22.—On January 22nd, at about six p. m. central standard time, a very brilliant meteor passed over the western borders of Iowa and Missouri. I immediately made arrangements to secure all the observations on its appearance throughout the four states of Iowa, Missouri, Kansas and Nebraska. About thirty observations which seemed to contain definite and reliable information have been secured. From this data it would appear that the meteor had a general direction from North to South, bearing slightly toward the East; that its path was at a considerable height, and that the place where it disappeared is not far from St. Joseph, Missouri. Reports from Mason City, Iowa, describe the meteor as very bright and appearing a little West of South. A report from Washta, Iowa, bears the same statement with the exception that it was seen in the South. The most northern reliable observation, made at Northfield, Minn., by Professor H. C. Wilson, and published in POPULAR ASTRONOMY for March, that "The course was at an angle of about 45 degrees with the horizon, descending toward the left and intersecting the horizon at about 20 degrees west of south" adds weight to the two above observations, since Northfield is due north of Mason City. A report from Carroll states that a fragment fell on the farm of Rudolph Peterson, three miles North of Creston. While the description of the fragment is scientifically untenable, it has some appearance of genuineness. The statement is that "It could not be approached for over twenty-four hours because it was so hot. It was about the size of a bushel basket. The segment (fragment) has the appearance of pumicestone and is apparently porous. There are particles of iron in the stone."

At Lamoni, the meteor was described as falling in the Northwest, followed by several heavy rolls of thunder. At Baxter, it is reported that two falling stars were seen to cross the sky. Rockwell City reports that "The glare from a meteor passing thru the sky in the *North* Tuesday evening frightened a team of horses hitched to a hayrack, causing a runaway." The farthest North from which there is any authentic report of a noise, is Mt. Ayr. The statement written to me personally from a former student is, "It was first seen coming from the North and West of this immediate vicinity. Just before it vanished from view it seemed to be much redder and looked to be going down. In just about ten minutes after we saw the meteor we heard a report as though a large shot gun had been discharged as at distance of about a quarter of mile. Immediately following the report we experienced a shock that rattled our doors and windows. The people of Mt. Ayr also experienced the shock, though not the report. Our first neighbor South, also heard the report and felt the shock in about ten minutes."

From St. Joseph, Missouri, the report is that "A small piece of the meteor hit the earth just East of the city limits at the home of Richard Tarwater. It struck in the yard close to the house, according to members of the family, and imbedded itself in the ground. There was a brilliant light lasting about thirty

seconds, but no noise," reported Mr. Tarwater. The most southern point reporting the meteor to date is Coffeeville, Kansas, where it is described as "Giving a

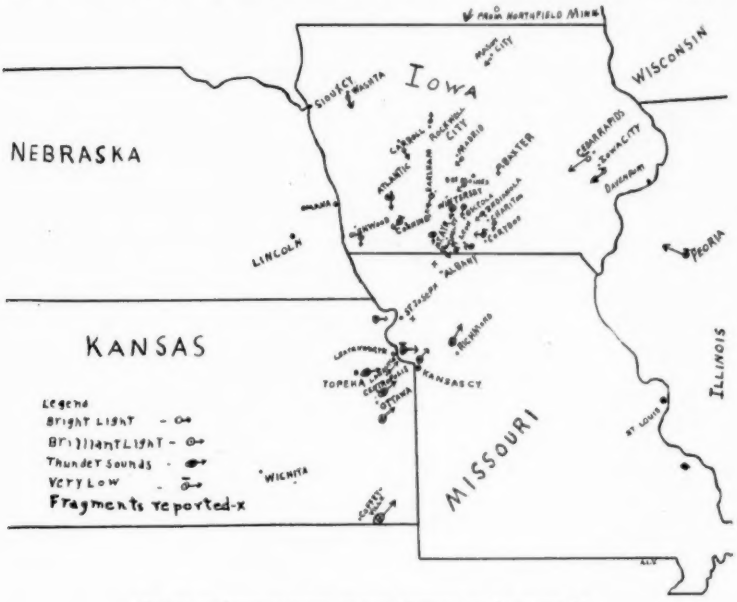


CHART OF OBSERVATIONS OF THE METEOR OF JANUARY 22.

lurid glare and passing from West toward the East, striking seemingly just North of town with such a force that the windows in the city rattled to such an extent that the people ran out thinking an explosion had occurred." At Richmond, Missouri, it was reported, "That a vivid white ball of fire traveling across the Northern sky appeared to burst high in the air and that the fragments were consumed before they reached the earth." Fragments were also reported from Albany, Missouri. The usual thin cloud of dust high in the sky was noted by practically every observer. The time of duration varied all the way from ten to thirty minutes.

D. W. MOREHOUSE.
Drake University, Des Moines, Ia.

The Aurora of March 7.—A brilliant, auroral display was observed quite generally throughout the United States on the night of March 7. The following are some of the reports which have come to hand concerning it:

AT NORTHFIELD. The display was on when twilight darkened and was still active at 10:45, when our watch upon it ceased. A great green arch extended from the western horizon at azimuth 100° to the eastern horizon at azimuth 280°, passing over the constellation Orion in its course. The arch was wide enough to more than cover Orion. It drifted slowly southward until the lower edge covered Sirius. A narrower arch of the same color occasionally formed and disappeared about midway between the great arch and the southern horizon. Above the great

arch was another arch of changeable color, red, yellow and greenish white, composed apparently of nearly vertical streamers, converging by perspective toward a point from 5° to 10° south of the zenith. This arch was very bright red, especially toward the west in azimuth 105°, where it persisted during nearly the whole of the hour from 7:15 to 8:15, after which clouds intervened for a time. During part of the time this arch passed over the Pleiades and Castor and Pollux. Toward the north the auroral display was less brilliant, but there was a low green arch and many comparatively narrow streamers of red and yellowish color converging toward the zenith.

At nine p. m., when the clouds partially cleared away, the red display had ceased and the green was less active, although it covered a large part of the sky. About 9:35 the red display again became active, but was mostly in the northern half of the sky. The great green arch in the southern sky broke up and almost completely vanished. Later the whole northern half of the sky was filled with streamers, mostly green, converging toward a point 10° south of the zenith.

A 60° prism spectroscope was turned upon the bright green arch and showed the auroral line as very strong, with four fainter lines almost equidistant from each other, the fourth being near the position of the F hydrogen line. The line at E was invisible or exceedingly faint. When the spectroscope was turned on a very bright red streamer one line could be seen in the red, not far from the *C* line of hydrogen. My impression was that this line was farther than *C* from the aurora line, but I had no means of measurement at hand. At times I thought I glimpsed a line in the yellow also, but I could not be sure of this.

As such auroral displays are usually associated with extraordinary activity in the sunspots, we took advantage of the next clear day to examine the sun's surface. On March 11, the first opportunity after March 7, a large group of spots was noticed near the central meridian of the sun on the northern hemisphere. The group was approximately 100,000 miles long and the chief spot nearly 20,000 miles in diameter, showing evidences of violent internal motions.

H. C. Wilson.

New Bedford, Mass. I am sending you a report of the most wonderful auroral display I have ever witnessed, and an occurrence which, I think, is exceedingly rare in such a low latitude (roughly +41° 30′), thinking it might be of interest to your readers in general and particularly to those making a study of this phenomenon, that they may make comparisons with reports from other observers of the same display elsewhere which doubtless will come to their attention.

The display occurred last evening (March 7th) lasting for several hours, the most active part of it being between 10 and 11 p. m., E. S. T. The heavens had just cleared after a snow storm which had lasted all day and the air was unusually still and quite crisp, the thermometer standing at 20° F.

At 10:30, when the activity was at its height, the entire northern sky was ablaze with greenish white light with countless streamers continuously darting up towards the zenith, the light being almost as bright as moonlight. But the activity was not confined to the northern sky by any means. The entire heavens, with the exception of a space of about 30° from the southern horizon, was covered with a luminous cloud-like formation very similar to the familiar "mare's tails" except that they were constantly changing form, appearing and disappearing, streaks from north, south, east and west converging in one small spot a little south of the zenith in the constellation Leo, just east of the Sickle. Very gradually, while all this was at its height, a faint orange red (in some places pinkish) glow appeared, arching the entire heavens from east to west. This glow slowly

deepened in color, advancing from light red successively through vermilion and crimson of different intensity in different parts of the sky, until it vanished in about half an hour's time as a very deep purple barely distinguishable from the ordinary color of the night sky. All through this beautiful glow the greenish light constantly waved and shimmered like a silk flag blown out by the breeze. The peculiar part of the display was that at the north, where the greenish light was the most vivid, there was not the faintest trace of the red glow, that not commencing until an altitude of 60° or more was reached, while it descended all the way to the horizon in the east and west.

The display made quite an impression in New Bedford, the newspaper offices receiving repeated inquiries in regard to it. VINCENT FRANCIS.

4 Sears Street, New Bedford, Mass., March 8, 1918.

PERU, NEBRASKA. We were favored here on the evening of March 7 by a magnificent display of Aurora Borealis. As soon as it was dark enough to see it, a great arch of pearly light appeared spanning the northern horizon, the center seeming to be a few degrees to the east of north. Here and there the arch would thicken and swell up like a great wave of light, from the crest of which streamers of greenish white, lavender and red would shoot up, reaching and even passing the zenith at times. As a climax these streamers would fuse into another arch which would drift southward and dissolve, leaving usually a cloudy mass of greenish white or rose red light at the northeastern and northwestern ends of the new arch. This phenomenon was repeated many times, until finally the new arch passed the zenith and reached as far south as the belt of Orion, almost coinciding with the equator. The most wonderful displays came from 9:30 to 10:00 o'clock when the colors ranged from pearly white, to greenish yellow, lavender, rose red, crimson and cerise, until the whole northern half of the sky was lurid with variegated flames. The great constellations Leo, Orion, Taurus, Auriga, Cassiopeia and Ursa Major were swamped but not annihilated by the gorgeous hues. Jupiter, Saturn and Mars did not swerve a hairsbreadth because of the threatening flames, though many were frightened by the fiery glare of the latter through the crimson light, and were convinced that it had erratic movements. At the climax, two great streamers of pearly white light, much like gigantic comets, appeared in the northeast and northwest, reaching two-thirds the distance to the zenith. After ten o'clock the exhibition gradually waned, until it was hidden by clouds about half past twelve. Altogether this was the finest display of Aurora ever recorded in this latitude. W. F. HOYT.

Peru State Normal School, March 11, 1918.

DES MOINES, IOWA. It was a beautiful clear night here and my first observations began at 7:30 and continued until 12:00 o'clock. I do not believe I have ever witnessed any auroral display comparable to it. The whole northern sky was aglow. The great arches extended at times almost to the zenith and the streamers at right angles to these arches reached well beyond the zenith. The prominent colors were green and red, the same color of red as we get in a feeble discharge in a hydrogen tube. I exposed some photographic plates. One was exposed toward the South ten degrees below the equator and was so badly fogged at the end of forty-five minutes that I could hardly distinguish any stars on it. If it was clear at Northfield, you probably got a better view of it than I did here.

D. W. MOREHOUSE.

GENERAL NOTES.

Request for Information as to Eclipse Observing Plans.—We are planning to give in the May issue of POPULAR ASTRONOMY an article, which will contain as complete a summary as possible of the preparations which are being made to observe the total solar eclipse of June 8, 1918. It will help us greatly if those who are planning expeditions for this purpose will write us, as soon as possible, brief accounts of their plans as to stations to be occupied, equipment to be employed, and observations to be made. The accounts should all be in by May 10, if possible.

Professor Joel Stebbins, director of the observatory of the University of Illinois, at Urbana, Ill., has leave of absence for a month and is teaching navigation to prospective merchant marine officers at the Navigation School in Cleveland, Ohio.

Dr. George E. Hale, director of the Mt. Wilson Solar Observatory of the Carnegie Institution of Washington, and chairman of the National Research Council, gave the second lecture in the series on science in relation to the war before the Washington Academy of Science on February 21. The subject of the lecture was "Astronomy and the War." (*Science,* March 1, 1918.)

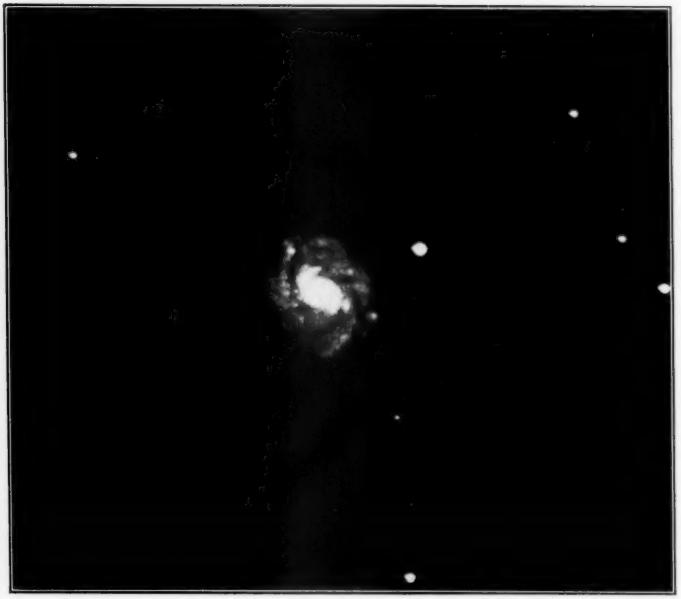
Dr. R. T. Crawford, associate professor of practical astronomy at the University of California, has been commissioned major in the aviation section of the Signal Corps and has been detailed for duty at the Balloon School at Fort Omaha. (*Science,* March 8, 1918.)

Professor Andrew Thomas Geiger Apple, who for the past ten years has occupied the Chair of Mathematics and Astronomy in Franklin and Marshall College, and who was the director of the Daniel Scholl Observatory, died at 8:50 o'clock on Tuesday morning, February 5, 1918. His death was due to angina pectoris, and came after an illness of two months. The news of his death came as an unexpected shock to the students and professors at college as well as to the late Professor's host of friends.

Professor Apple suffered an attack of heart trouble shortly before Christmas, and was removed to the General Hospital. His illness was by no means serious, and his friends at college held firm hopes that he would be able to meet his classes after the Christmas vacation. However, at the beginning of this year, although he was decidedly improving, he thought it advisable to discontinue teaching for the remainder of this term. Since that time his condition has gradually grown better until a few days ago when it showed a sudden decline.

Professor Apple was born at Hamburg, Pa., March 5, 1858. He received his preliminary education at Clarion Collegiate Institute, Rimmersburg, Pa., and at the Germantown, Ohio, High School. He was graduated from Franklin and Marshall College in 1878 and from the Eastern Theological Seminary in 1883. From 1880 to 1883 he was Professor of Natural Sciences, Palatinate College, Myerstown, Pa. From that time on until he became a Professor in Franklin and Marshall College he was pastor of charges in Bedford County, Washington, D .C., Catawissa and Bedford, Pa. Since 1907 he has occupied a Chair at Franklin and Marshall College.

PLATE XII



THE SPIRAL NEBULA N. G. C. 1068 (M77, CETI).

For a number of years he had charge of the Astronomical Almanac of the Reformed Church. He was the Secretary-Treasurer of the Phi Beta Kappa Fraternity; a member of the Diagnothian Literary Society, and a member of the Phi Kappa Psi Fraternity. He also was a member of various astronomical societies and at various times contributed articles to scientific periodicals.

But by far his most important works were his observations on Jupiter in conjunction with the British Astronomical Society. His observations gained recognition not only in America, but in Europe as well, and they brought deserving honors to him and to the college with which he was associated.

Professor Apple's inclination toward the sciences came as a result of his contact with his uncle, the late Theodore Apple, who was also Professor of Mathematics at Franklin and Marshall College. The deceased early showed an affection for this form of work and promised to distinguish himself in the realm of science. Even though he spent twenty-four years of his life as a minister in the Reformed Church, he never diminished but rather increased the satisfaction he derived from the study of the heavens. Yet he was a distinguished scholar in other scientific lines; a minister whose sermons bore the imprint of one deeply rooted and grounded in the Christian faith; a student of philosophy and art, and a Christian gentleman of splendid virtues. In every sense, "he was a man."

The Lancaster funeral services of the late Professor A. T. G. Apple were held Friday morning, February 8, 1918, in the First Reformed Church. The students of the College attended in a body to pay a last tribute to their beloved Professor.

After the funeral services in Lancaster, Pa., the body was sent to Littlestown, Pa., where the rites were concluded and the body interred. (From *Student-Weekly*, Franklin and Marshall College.)

The Nebula N. G. C. 1068 (M77).—This little nebula, about one degree southeast of the star δ *Ceti*, has perhaps the highest velocity of all the heavenly bodies now known. Two other spiral nebulae, N. G. C. 4565 and 4594, have nearly as great velocities. They are in roughly the opposite part of the heavens and receding, as is N. G. C. 1063.

It is difficult to conceive how such enormous velocities (over 1000 kilometers per second) can have been generated, limiting one's self to purely physical considerations and the assumption of the universality of the law of gravitation. There does not appear to be evidence of the existence of enough matter in the whole sidereal universe, so far as our telescopic vision has penetrated, to have produced such acceleration, even though the nebulæ should have fallen from infinity and should now be very near the center of the universe. These nebulæ, however, appear to be many thousands of light-years apart and cannot all be close to the center.

In the *Lowell Observatory Bulletin* No. 80, Director V. M. Slipher gives a discussion of "The Spectrum and Velocity of the Nebula N. G. C. 1068 (M77)" in which he verifies the enormous velocity by measures of two spectrograms obtained with the 40-inch reflector in 1917, one of which was given an exposure of thirty-five hours. The following are the velocities determined from the four spectrograms obtained at Flagstaff in 1913 and 1917:

Date	Velocity
1913 November 6	+1060 km
1913 November 22, 23	+1150 "
1917 November 6, 7, 8	+1080 "
1917 November 12 to 16, two prisims .	+1130*s* "
	+1145*c* "
	+1135*c* "
Mean velocity	+1120 km

"The measures were made upon the emission lines N1, N2, Hβ, and Hγ, and upon the dark lines and bands chiefly in the Hγ region which apparently are the same as those of the solar spectrum used as standard in the comparator measurements.

"The last plate was thrice measured, once with the screw measuring engine and twice with the spectrocomparator, and the three results are given separately. The single prism plates were measured with the comparator."

Besides indicating the high velocity of the nebula as a whole, the lines are inclined through an angle of about five degrees, indicating a rotation of the nebula about its shortest axis, the speed of rotation amounting to about 300 km per second at a distance of 1′ from the nucleus. This rotational speed is higher than that of any other object yet observed, that of the nebula in Virgo, N. G. C. 4594 being the next highest. If we read Mr. Slipher's interpretation of the spectrograms and direct photographs of the nebula correctly the rotation is inward, ... "the inner part of the nebula (all that is recorded on the spectrograms) is turning into the arms of the spiral like a winding spring."

The reproduction (Plate XII) is from a photograph by Keeler with the Crossley Reflector, copied from the "Publications of the Lick Observatory" Vol. VIII, Plate 7.

A letter received from Director Slipher after this note was in type confirms the above statement. Mr. Slipher also states that the — sign was given inadvertently to the velocity in Bulletin No. 80. It should be + as given in this note.

Daylight Saving.—On March 15 Congress passed the Daylight Conserving Bill. According to the terms of the bill all clocks and watches in the United States are to be set forward one hour at 2 a. m. Sunday, March 31. The new time will prevail until 2 a. m. Sunday, October 27, when the timepieces will be set back one hour, and correspond again to the present standard time.

It will be a remarkable achievement if this can be accomplished without confusion or friction over such a wide extent of country as is covered by the United States, but we believe that the people, as a whole, are so loyal to the government that it will be done.

In the observatories it will be necessary to change only one clock to read "Summer Time" for public use, the others remaining on astronomical time the year round, so that astronomical records need not be interfered with.

Nova Monocerotis.—The position of the new star in Monoceros has been determined by Professor Barnard as

R.A.1918.0 $7^h\ 22^m\ 46^s.93$ Dec. 1918.0 —6° 30′ 34″.7.

According to the observers at the Lick Observatory the "spectrum has reached the nebular stage, consisting of extremely broad bright bands of hydrogen; nebulium moderately strong; absorption near centers of green bands." Photographs of the spectrum taken at the Harvard College Observatory on February 21 with the 24-inch reflector show the hydrogen lines Hζ, Hε, Hδ, Hγ, Hβ and Hα as bright lines. Bright lines are shown also at wave-lengths 4363, 4520, 4686, 5007, 5440, 5630 and 5750. The strongest lines are Hγ and Hα.

"Observatory Hill, B. C."—When the new astrophysical observatory was located in British Columbia its site was known as Little Saanich Mountain, but henceforth it will go down to fame as Observatory Hill. The change was made by the Geographical Board of Canada, at the suggestion of Dr. J. S. Plas-

kett. At the same time Big Saanich Mountain, a little to the west, had its name changed to Mount Wark, a name associated with the early history of the city of Victoria.

I learn also that the spectroscope has been placed in position on the great reflector. (C.A.C. in *The Journal* of the Royal Astronomical Society of Canada, March 1918.)

Solar Constant Observations in South America.—The Astrophysical Observatory of the Smithsonian Institution has not yet been able to carry out its plan of establishing a station for solar-constant work in South America, although an appropriate site has been found, with a record of 300 cloudless mornings per annum for observing. The equipment for this station was all prepared and packed, when conditions arising from the war made it necessary to postpone the undertaking. The expedition was accordingly sent, temporarily, to Hump Mountain, North Carolina, a station at 4,800 feet elevation and ordinarily favored with clear skies, though it is stated that the weather during 1917 was the cloudiest and rainiest heretofore known in that region. The preparation of equipment for this station led to valuable improvements in the bolometer and the pyranometer, and to the invention of a new instrument for avoiding computation in reducing spectrobolometric observations. (*Scientific American* March 2, 1918.)

One Hundred New Double Stars.—In the *Lick Observatory Bulletin* No. 30 Dr. Aitken gives his twenty-fourth list of new double stars, which raises the total of doubles discovered by him to 3000. His systematic survey of the sky, with the 36-inch refractor initiated in April 1899, was completed in 1915 for the area from the north pole down to —14° declination. Between 13^h0 and 1^h0 it was completed down to —22° declination. The majority of the pairs in the new list had been discovered in that survey, but were not seen as certainly double and were marked for re-examination. A number of them are very close and difficult pairs.

Size of the Particles of Saturn's Rings.—In POPULAR ASTRONOMY of January 1918, page 78, there was described an occultation of a small star by the outer ring of Saturn, important as furnishing some observational evidence of the size of the little satellites of which the ring is made up. I think the matter must be looked at from another point of view from that there taken, in order to draw any well founded conclusions.

In that article an upper limit to the size of the satellites was obtained by questioning how large they might be without entirely covering a star disc of an assumed size, it being also assumed that a complete occultation of the star would have been observable, had it occurred.

Now the particles in the ring being in motion, if they were small enough and their motion rapid enough, an occultation might last so short a time as to be entirely obscured by persistence of vision; as it would be shortly followed by another occultation, partial or complete, and that again by another, the aggregate effect might be a diminution of brightness seemingly constant. So it is important to knew the effect of the velocity of the particles across the star.

This velocity is made up of two components—that due to the transverse motion of Saturn across the sky, and that due to the motion of the particles about Saturn. The former, using the values of the apparent hourly motion of Saturn in R.A. and declination, and for his distance at the time in question, from the Nautical Almanac; is easily computed to be 11.5 miles per second. The velocity of a

particle in the outer part of the ring, computed from the velocity of the first satellite by Kepler's law, is about 10.5 miles per second. The component of this last velocity, which is perpendicular to the line of sight, may be guessed closely enough from the drawing in POPULAR ASTRONOMY as about 6 miles per second. Accuracy is not essential.

As the above velocities happen to be in such directions as to add, we have the apparent velocity of the particle across the star as 17.5 miles per second.

We must now consider the apparent size of the star disc at Saturn's distance. If the star were 2,000,000 miles in diameter, and its parallax 0".01, this is easily computed to be 0.8 mile.

Now if the particles in Saturn's ring were 6 miles in diameter, the occultation, if central, would last about 1-3 second, and would surely be seen; if the particles were 3 miles in diameter, the occulation would be total for about 1-8 second, and might still be seen, for persistence of vision is said to last about 1-10 second, while motion pictures, which blend well into each other, are 1-14 second apart. A smaller particle than 3 miles in diameter would cause an occultation so short than it is very doubtful whether it could be discerned.

So it appears that the conclusions of this more elaborate discussion are about the same as those of the original one: the particles of Saturn's ring cannot well be more than three or four miles in diameter. O. H. TRUMAN.

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The Royal Astronomical Society.—At the anniversary meeting of the Royal Astronomical Society held on February 8 the officers and council elected, as recorded in *Nature,* are as follows: *President,* Major P. A. MacMahon; *Vice-presidents,* Professor A. S. Eddington, Dr. J. W. L. Glaisher, Professor R. A. Sampson and Professor H. H. Turner; *Treasurer,* Mr. E. B. Knobel; *Secretaries,* Dr. A. C. D. Crommelin and Professor A. Fowler; *Foreign Secretary,* Dr. A. Schuster; *Council,* Mr. A. E. Conrady, the Rev. A. L. Cortie, S. J., Dr. J. L. E. Dreyer, Sir F. W. Dyson, Colonel E. H. Hills, Mr. J. H. Jeans, Mr. H. S. Jones, Mr. E. W. Maunder, Dr. W. H. Maw, Professor H. F. Newall, Professor J. W. Nicholson and the Rev. T. E. R. Phillips. (*Science,* March 15, 1918.)

Lessons in Astronomy, including uranography. A brief introductory course without mathematics, by Charles A. Young. Revised by Anne Sewell Young, Professor of Astronomy, Mount Holyoke College. Published by Ginn & Company, 1917.

This new edition of Young's "Lessons in Astronomy" will be welcomed by teachers of elementary astronomy. It is fourteen years since the book, originally published in 1891, was revised by its author. The present revision has been done by Professor Young's niece, who is in charge of the department of astronomy of Mount Holyoke College. While much of the book stands as it was originally written, in all essential particulars it has been brought up to date. The press-work on the book is excellent and the illustrations are good.

Proof of the Rotundity of the Earth.—A French teacher having received from her pupils the usual classical proofs that the earth is a sphere, said to them, "But you have forgotten *the Rainbow*!"